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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See page 111. 6455
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6977
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See Full Page Advt., page 76, Dec. 13.

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6186
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See half-page Advertisement page 58, Nov. 29.

The Manchester Steam Users' Association.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.
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Patent and Designs Act, 1907.

Notice is Hereby Given that

HUGH REGINALD LAMB, of Birmingham City Gas Works, Saltley, Birmingham, Electrical Engineer, Seeks Leave to Amend the Specification left in connection with the application for Letters Patent, No. 119383, for "Improvements in and relating to Insulators for supporting Electric Conductors."

Particulars of the proposed amendment were set forth in the Illustrated Official Journal (Patents), issued on the 11th December, 1918.

Any person or persons may give notice of opposition to the Amendment by leaving Patents Form No. 18, at the Patent Office, 25, Southampton Buildings, London, W.C., within one Calendar month from date of the said Journal.

W. TEMPLE FRANKS,
Comptroller General.

Agents for Applicant, George Barker & Brettell, Birmingham. R 462

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Association of Engineering and Shipbuilding Draughtsmen.

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PETER DOIG, General Secretary,
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Employers are invited to use the facilities of the Association for this purpose.

R 251

UNIVERSITY OF BRISTOL.
DEMOBILISATION.

Special Regulations have been

made to allow intending students who have served in the war or in the scientific service of the war to be admitted to matriculation by vote of Senate on their educational qualifications, without formal examination; and also to allow of such students entering the University in January if candidates in Arts; in January, or between January and May, if candidates in Science, Medicine, Dental Surgery or Engineering; and if grounds be shown, counting their first year's attendance as though it had commenced in October. Engineering students in special cases may be allowed to count one whole year's attendance.

The Special Army Education Certificate qualifies for Matriculation.

Applications to the REGISTRAR. O 722

THE

Technical College,

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W. A. BROCKINGTON, O.B.E., M.A.,
Director of Education.

O 978

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Reference:—The Commercial Department of the British Legation, The Hague.

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Telegrams:—COOPRA, Rotterdam. R 439

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Director of Education. R 206

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Applications should be sent at once in covers marked "C.A." to the SECRETARY, Board of Education, Victoria and Albert Museum, London, S.W. 7. Scottish candidates should apply to the Secretary, Scotch Education Department, Whitehall, London, S.W. 1. R 350

SWINDON EDUCATION COMMITTEE.

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Principal: Mr. G. H. Burkhardt, M. Sc.

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W. SHATON, Secretary.

Education Offices,
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H. SALTER DAVIES,
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December, 1918. R 148

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Applications (which need not be accompanied by testimonials) must be on forms to be obtained from the Clerk of the Board, 2, South Place, Finsbury Pavement, London, E.C. 2, and must be delivered to, him at that address in sealed envelopes endorsed CHIEF ENGINEER, not later than 10 o'clock a.m. on the 1st February, 1919. Personal canvassing is strictly prohibited and will disqualify candidates.

A. B. PILLING,
Clerk of the Board.

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23rd November, 1918. O 859

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organise and control Sheet Metal Department in large aeroplane factory. Applicants must be experienced and reliable, capable of developing all classes of sheet metal work at competitive rates. Only men with up-to-date experience of modern methods will be considered.—Apply, stating age, experience, and salary required, to R 347, Offices of Engineering.

Engineer Wanted for Grain

and General Drying Works Practical working Manager. Good salary to competent man.—Write, with full particulars to M. B., care of Street's, 30, Cornhill, London, E.C. 3. R 353

AN APPROXIMATE GRAPHICAL TREATMENT OF SOME STRUT PROBLEMS.

By JOHN CASE, M.A., A.F.Ac.S.

§1. IN an article on the "Whirling of Shafts," published in ENGINEERING last November, Mr. H. A. Webb introduced a method of graphical analysis which is of great power and may be used for the solution of many problems. In the present paper it is shown how to apply the method to problems connected with the strength of structural members which may or may not be loaded laterally, and which also carry end loads, the section of the member varying along its length. The results and formulæ are given first, the proofs being left to the end of the paper.

§2. *The Crippling Load of a Pin-Jointed Strut of Varying Section.*—Referring to Fig. 1, x is measured along the centre line of the strut, the middle point being the origin; I is the moment of inertia of the cross-section about a line perpendicular to O A, and the plane xy; l is the length of the strut measured between the points of support A and B. The centres of gravity of all the sections are supposed to lie on the straight line O A.

If P = the Euler crippling load of the strut, and E = Young's modulus, then, if we assume, as is approximately true, that the deflection curve can be taken as a simple cosine curve, if there be symmetry about O y:

$$\frac{E}{P} = \int_0^{\frac{l}{2}} \int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx \quad . \quad . \quad (1)$$

The integration can be done on squared paper very quickly, as will be seen from the following example:—

Example.—A pin-pointed strut is 81·6 in. long, and the moments of inertia of the cross-sections are given by curve 1 in Fig. 2.

The calculations are best done in tabular form. After filling in the fifth row, the curve 2 is drawn. The area under this, for successive values, of x is found, the last row filled in, and the curve 3 is drawn. The area of this last is the value of the double integral in formula (1); the area is 9·34 in.².

The value of E for this strut is $2{\cdot}5 \times 10^6$ lb./in.², and the scales of the curves are:

1 in. = 10 units of 1

1 in. = 0·1 units of $\frac{\cos \frac{\pi X}{l}}{I}$

1 in. = 4 sq. in. of area of the curve 2.

The crippling load P is found from:

$$\frac{2{\cdot}5 \times 10^6}{P} = 0{\cdot}05 \times 10 \times 2 \times 10 \times 9{\cdot}34 = 93{\cdot}4$$

$$\therefore \quad P = 26{,}800 \text{ lbs.}$$

§3. If the strut has not symmetry about Oy, the crippling load P is given by:

$$\frac{2E}{P} = \int_0^{\frac{l}{2}} \int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx + \int_0^{\frac{l}{2}} \int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx \quad (2)$$

where the integration is performed in the same way.

§4. If each half of the strut be the same as half of a strut whose crippling load is known, the crippling load of the actual strut may be found at once from the formula:

$$\frac{2}{P} = \frac{1}{P_1} + \frac{1}{P_2} \quad . \quad . \quad . \quad (3)$$

where P = the required crippling load. P_1 = the crippling load of a strut, each half of which is the same as the half O A, say, of the strut in question, and P_2 = the crippling load of a strut, each half of which is the same as the half O B.

§5. *The Deflection of a Strut with Lateral Load.*—If, in addition to the end load P, there be a distributed load w (constant) per unit length, the deflection a, at the centre, is given by graphical integration from the equation:

$$a\left[1 - \frac{P}{E}\int_0^{\frac{l}{2}}\int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx\right] = \frac{wl^2}{8E}\int_0^{\frac{l}{2}}\int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx \quad . \quad . \quad (4)$$

x (ins).	0	5	10	15	20	22·5	25	27·5	30	32·5	35	37·5	40·8
$\frac{\pi x}{l}$	0	0·192	0·385	0·576	0·77	0·866	0·962	1·058	1.155	1·25	1.346	1·443	1·57
$\cos \frac{\pi x}{l}$	1	0·98	0·926	0·839	0·718	0.649	0·572	0·4906	0·404	0·315	0·223	0·127	0
I (ins.⁴)	7·3	7·3	7·3	7·3	7·0	6·8	6·3	5·5	4·3	3·3	2·4	1·4	0.3
$\frac{\cos \frac{\pi x}{l}}{I}$	0·137	0·134	0·127	0·115	0.1025	0·0955	0·091	0.0893	0·094	0·0955	0·093	0.091	0
$\int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx$	0	1·15	2·46	3·66	4·75	—	5·7	—	6·61	—	7·53	—	8·45

Fig.1.

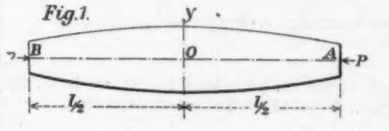


Fig.2.

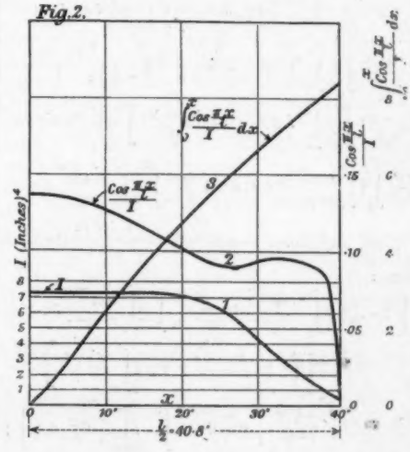


Fig.3.

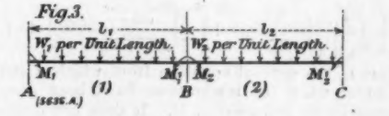
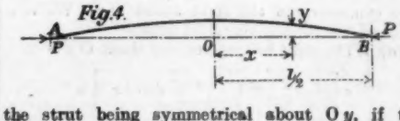


Fig.4.



the strut being symmetrical about Oy, if the deflection curve assumed to be as before of the cosine type.

If I be constant this leads to the well-known formula:

$$a = \frac{wl^2}{8(P_E - P)}$$

where P_E is the Euler crippling load.

§6. *The Deflection of a Strut Subjected to Lateral Load and Terminal Couples.*—If the couples applied at the ends are M_1 and M_2, reckoned positive when they tend to deflect the strut in the same direction as w, the deflection, a at the centre, can be found from:

$$a\left(1 - \frac{P}{E}\int_0^{\frac{l}{2}}\int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx\right) = \frac{wl^2}{8E}\int_0^{\frac{l}{2}}\int_0^x \frac{\cos \frac{\pi x}{l}}{I} dx . dx + \frac{M_1 + M_2}{2E}\int_0^{\frac{l}{2}}\int_0^x \frac{dx}{I} dx . \quad (5)$$

The more general equation for an unsymmetrical strut will be found in §10.

If I be constant this leads to:

$$a = \frac{\frac{wl^2}{8} + \frac{\pi^2}{16}(M_1 + M_2)}{P_E - P} \quad . \quad (6)$$

a formula which will be found extremely useful. As examples of its accuracy the two following examples are cited:—

	l	w	M_1	M_2	P_E	P	P/P_E	a (ins).
(i.)	64·8	8·85	−3040	−4300	9530	6694	0·704	1·230
(ii.)	90·0	8·85	1150	−8440	4940	3495	0·710	0·761

The correct value of a in (i) is 1·215 in., and in (ii) it is 0·731 in. The latter is particularly interesting as the deflection curve really crosses the initial centre line.

§7. *Continuous Beams with End-Load.*—If the strut be freely pinned at several points along its length, like a "continuous beam" we can deduce a "theorem of three moments" from which the values of the bending moments at the points of support can be found. If I and w be constant for each span, the equation is:

$$l_1 M_1 \left(1 + \frac{\pi^2}{8}\frac{P_1}{P_{E1} - P_1}\right) + l_1 M'_1 \left(2 + \frac{\pi^2}{8}\frac{P_1}{P_{E1} - P_1}\right) + l_2 M_2 \left(2 + \frac{\pi^2}{8}\frac{P_2}{P_{E2} - P_2}\right) + l_2 M'_2 \left(1 + \frac{\pi^2}{8}\frac{P_2}{P_{E2} - P_2}\right)$$

$$+ \frac{w_1 l_1^3}{4} \cdot \frac{P_{E1}}{P_{E1} - P_1} + \frac{w_2 l_2^3}{4} \cdot \frac{P_{E2}}{P_{E2} - P_2} = 0 \quad . \quad (7)$$

The notation is, for the most part, explained in Fig. 3. The meanings of the other symbols are:

P_1 = the end thrust on the bay (1)

P_{E1} = the Euler crippling load for this bay

$M_1' \sim M_2$ = the external applied couple at B, if any.

PROOFS OF THE ABOVE FORMULÆ.

§8. *Pin-jointed Strut under End Load only.*—Referring to Fig. 4, we have:

$$-EI\frac{d^2y}{dx^2} = Py$$

Now, let m be value of $\frac{dy}{dx}$ at the centre, then, for the half A O, we can write

$$\frac{dy}{dx} = \int_x^0 \frac{Py}{EI} + m$$

and, for O B,

$$\frac{dy}{dx} = -\int_0^x \frac{Py}{EI} + m$$

Integrating these we have, for O A,

$$y = m\left(x + \frac{l}{2}\right) + \int_{-\frac{l}{2}}^x \int_x^0 \frac{Py}{EI} dx\, dx$$

and for O B,

$$y = m\left(x - \frac{l}{2}\right) + \int_x^{\frac{l}{2}} \int_0^x \frac{Py}{EI} dx\, dx$$

These satisfy the condition $y = 0$ when $x = \frac{l}{2}$.

At the centre, when $x = 0$, we have

$$a = \frac{ml}{2} + \int_{-\frac{l}{2}}^0 \int_x^0 \frac{Py}{EI} dx\, dx$$

and

$$a = \frac{-ml}{2} + \int_0^{\frac{l}{2}} \int_0^x \frac{Py}{EI} dx\, dx.$$

Where a is the deflection at the centre, Now if we eliminate a, the resulting equation gives the condition for which a is indeterminate, and the value of P which satisfies this relation is the critical load for the strut. By addition we have

$$2a = \int_{-\frac{l}{2}}^0 \int_x^0 \frac{Py}{EI} dx\, dx + \int_0^{\frac{l}{2}} \int_0^x \frac{Py}{EI} dx\, dx \quad (8)$$

Now y is a continuous function of x, which is zero when $x = \pm \frac{l}{2}$. Assume

$$y = a \cos \frac{\pi x}{l},$$

this is zero when $x = \pm \frac{l}{2}$, and has the correct value, a, when $x = 0$. Thus the real curve of y and the assumed curve coincide at three points, and the difference between th ir values is at no point large. Therefore, the difference between their second integrals is everywhere small. Moreover, the assumption of a cosine curve for the deflection curve of a strut agrees with the theory of the simple parallel Euler strut. Making this substitution in (i) we have :

$$\frac{2E}{P} = \int_{\frac{l}{2}}^{0}\int_{x}^{0} \frac{\cos\frac{\pi x}{l}}{I}\,dx.dx + \int_{0}^{\frac{l}{2}}\int_{0}^{x} \frac{\cos\frac{\pi x}{l}}{I}\,dx.dx \quad \text{(ii)}$$

which is the same as the formula (ii) above.

If the strut be symmetrical about O y, this gives formula (i) above :

$$\frac{E}{P} = \int_{0}^{\frac{l}{2}}\int_{0}^{x} \frac{\cos\frac{\pi x}{l}}{I}\,dx.dx \quad . \quad . \quad \text{(iii.)}$$

If I be constant this gives the usual formula

$$P = \frac{\pi^2 E I}{l^2}.$$

§ 9. Proof of the formula (iii.) in § 4.—

$$\frac{2}{P} = \frac{1}{P_1} + \frac{1}{P_2}$$

where P_1 is the crippling load of a strut, the two halves of which are like O A, Fig. 5, and P_2 is that of a strut, the two halves of which are like O B. From (iii) we have :

$$\frac{E}{P_1} = \int_{0}^{\frac{l}{2}}\int_{0}^{x} \frac{\cos\frac{\pi x}{l}}{I_1}\,dx.dx = \int_{-\frac{l}{2}}^{0}\int_{x}^{0} \frac{\cos\frac{\pi x}{l}}{I_1}\,dx.dx,$$

on account of symmetry, and

$$\frac{E}{P_2} = \int_{0}^{\frac{l}{2}}\int_{0}^{x} \frac{\cos\frac{\pi x}{l}}{I_2}\,dx.dx = -\int_{-\frac{l}{2}}^{0}\int_{x}^{0} \frac{\cos\frac{\pi x}{l}}{I_2}\,dx.dx$$

Hence from (ii), we easily have

$$\frac{1}{P_1} + \frac{1}{P_2} = \frac{2}{P}.$$

§10. Strut with Lateral Load and Terminal Couples.

Let w = the constant distributed load per unit length.

Taking the origin at the centre of the beam, we have, with the notation of Fig. 6.

$$-EI\frac{d^2y}{dx^2} = Py + \frac{M_1 + M_2}{2} + \frac{x}{l}\left(M_2 - M_1\right) + \frac{wl^2}{8}\cos\frac{\pi x}{l}$$

where $\frac{wl^2}{8}\cos\frac{\pi x}{l}$ is written* instead of $\frac{w}{2}\left(x^2 - \frac{l^2}{4}\right)$.

For A O we have, if m be the value of $\frac{dy}{dx}$ at O,

$$\frac{dy}{dx} = m + \int_{x}^{0}\frac{Py}{EI}\,dx + \frac{M_1 + M_2}{2E}\int_{x}^{0}\frac{dx}{I} + \frac{M_2 - M_1}{El}\int_{x}^{0}\frac{x\,dx}{I} + \frac{wl^2}{8E}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.$$

and, for O B

$$\frac{dy}{dx} = m - \int_{0}^{x}\frac{Py}{EI}dx - \frac{M_1 + M_2}{2E}\int_{0}^{x}\frac{dx}{I} - \frac{M_2 - M_1}{El}\int_{0}^{x}\frac{x\,dx}{I} - \frac{wl^2}{8}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.$$

Integrating again and remembering that $y = 0$ when $x = \pm\frac{l}{2}$, we have for A O :

$$y = m\left(x + \frac{l}{2}\right) + \int_{-\frac{l}{2}}^{x}\int_{x}^{0}\frac{Py}{EI}\,dx.dx + \frac{M_1 + M_2}{2E}\int_{-\frac{l}{2}}^{x}\int_{x}^{0}\frac{dx}{I}\,dx + \frac{M_2 - M_1}{El}\int_{-\frac{l}{2}}^{x}\int_{x}^{0}\frac{x\,dx}{I}\,dx + \frac{wl^2}{8E}\int_{-\frac{l}{2}}^{x}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx$$

and, for O B. :

$$y = m\left(x - \frac{l}{2}\right) + \int_{x}^{\frac{l}{2}}\int_{0}^{x}\frac{Py}{EI}\,dx.dx + \frac{M_1 + M_2}{2E}\int_{x}^{\frac{l}{2}}\int_{0}^{x}\frac{dx.dx}{I} + \frac{M_2 - M_1}{El}\int_{x}^{\frac{l}{2}}\int_{0}^{x}\frac{x}{I}dx.dx + \frac{wl^2}{8E}\int_{x}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx$$

Fig. 5.

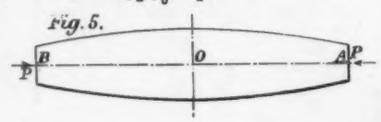


Fig. 6.

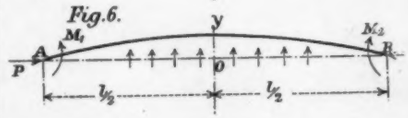
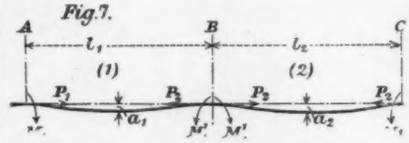


Fig. 7.



Hence, at the centre, where $x = 0$, we have, by addition, if a = the deflection at the centre,

$$2a = \int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{Py}{EI}dx.dx + \int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{Py}{EI}dx.dx + \frac{M_1 + M_2}{2E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{dx.dx}{I} + \frac{M_1 + M_2}{2E}\int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{dx.dx}{I} + \frac{M_2 - M_1}{El}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{x}{I}dx.dx + \frac{M_2 - M_1}{El}\int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{x}{I}dx.dx + \frac{wl^2}{8E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx + \frac{wl^2}{8E}\int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx$$

Now, as before, assume $y = a\cos\frac{\pi x}{l}$, then we have :

$$a\left[2 - \frac{P}{E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx - \frac{P}{E}\int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx\right] + \frac{M_1 + M_2}{2E}\left[\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{dx.dx}{I} + \int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{dx.dx}{I}\right] + \frac{M_2 - M_1}{El}\left[\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{x}{I}\,dx.dx + \int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{x}{I}\,dx.dx\right] + \frac{wl^2}{8E}\left[\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}dx.dx + \int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{\cos\frac{\pi x}{l}}{I}dx.dx\right] \quad \text{(iv.)}$$

This is the general equation from which a can be found when the integrations have been done graphically as indicated in §1. It does not imply any symmetry in the strut about O y. We now proceed to various simplifications :—

(a) If the strut be symmetrical about O y*

$$a\left[l - \frac{P}{E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx\right] = \frac{M_1 + M_2}{2E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{dx.dx}{I} + \frac{w}{8E}\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx \quad \text{(v.)}$$

which is the formula (5) above.

*It is easy to show that, in this case,

$$\int_{-\frac{l}{2}}^{0}\int_{x}^{0}\frac{x}{I}\,dx.dx = -\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{x}{I}\,dx.dx$$

so that the terms involving $\frac{M_2 - M_1}{El}$ cancel.

(b) If we put $M_1 = M_2 = 0$ we obtain the formula (4.) If I is constant along the beam :

$$\int_{0}^{\frac{l}{2}}\int_{0}^{x}\frac{\cos\frac{\pi x}{l}}{I}\,dx.dx = \frac{l^2}{\pi^2}\cdot\int_{0}^{\frac{l}{2}}\int_{0}^{x}dx.dx = \frac{l^2}{8}$$

$$\int_{0}^{\frac{l}{2}}\int_{x}^{0}x\,dx.dx = -\int_{0}^{\frac{l}{2}}\int_{0}^{x}x\,dx.dx = -\frac{l^3}{48}$$

∴ from (v.) we have :

$$a\left[1 - \frac{P}{\pi^2}\frac{l^2}{EI}\right] = \frac{M_1 + M_2}{2EI}\frac{l^2}{8} + \frac{wl^4}{8\pi^2 EI}$$

whence

$$a = \frac{\frac{\pi^2}{16}(M_1 + M_2) + \frac{wl^2}{8}}{P - P} \quad . \quad . \quad \text{(vi.)}$$

where $P_E = \frac{\pi^2 E I}{l^2}$,

which is formula (6) above.

§11. *Continuous Beam with End Loads, and Couples applied at the Points of Support.*—The following analysis is not rigidly correct, but is found to give good results in practice provided P is not greater than about 75 per cent. to 80 per cent. of P_E. The error lies in the fact that we assume that the deflection at the centre of a bay is the same as the maximum deflection, which is obviously not true; it is further assumed that the fixing couples at the points of support due to the bending moments caused by the thrusts are related to one another in the same way as the couples due to a distributed load. In spite of these rather wild assumptions it is surprising what good results are obtained in practice by using the formula given, below and in §7.

Let the notation be as shown in Fig. 7, and let w_1 and w_2 be the distributed loads on the two bays.

The fixing couples are counted positive when acting so as to cause deflection in the same direction as the distributed load and :

$M_3 - M'_1$ = the external applied couple at B.

Let I_1 and I_2 be the moments of inertia of the beam in the bays (1) and (2).

Then the end loads P_1 and P_2 cause bending moments at the centres of the bays equal to $P_1 a_1$ and $P_2 a_2$ respectively. These are the same as would be caused by distributed loads $\frac{8 P_1 a_1}{l_1^2}$ and $\frac{8 P_2 a_2}{l_2^2}$ per unit length. If we suppose that these hypothetical distributed loads can be added to the loads w_1 and w_2 we can write down the equation of three moments in the form :

$$(M_1 + 2M'_1)\,l_1 + (2M_2 + M'_2)\,l_2 + \tfrac{1}{4}(w_1 l_1^3 + w_2 l_2^3) + 2(P_1 l_1 a_1 + P_2 l_2 a_2) = 0 \quad . \quad \text{(vii.)}$$

From (vi.) we have

$$a_1 = \frac{\frac{w_1 l_1^2}{8} + \frac{\pi^2}{16}(M_1 + M'_1)}{P_{E1} - P_1}$$

and

$$a_2 = \frac{\frac{w_2 l_2^2}{8} + \frac{\pi^2}{16}(M_2 + M'_2)}{P_{E2} - P_2}$$

where

$$P_{E1} = \frac{\pi^2 E I_1}{l_1^2} \text{ and } P_{E2} = \frac{\pi^2 E I_2}{l_2^2}$$

Substituting these values of a_1 and a_2 in (vii.) we obtain

$$l_1 M_1\left(1 + \frac{\pi^2}{8}\frac{P_1}{P_{E1} - P_1}\right) + l_1 M'_1\left(2 + \frac{\pi^2}{8}\frac{P_1}{P_{E1} - P_1}\right) + l_2 M_2\left(2 + \frac{\pi^2}{8}\frac{P_2}{P_{E2} - P_2}\right) + l_2 M'_2\left(1 + \frac{\pi^2}{8}\frac{P_2}{P_{E2} - P_2}\right) + \frac{w_1 l_1^3}{4}\frac{P_E}{P_{E1} - P_1} + \frac{w_2 l_2^3}{4}\frac{P_E}{P_{E2} - P_2} = 0$$

which is the equation given above in §7.

§ 12. *Members in Tension.*—Formulæ (2), (4), (5), (6) and (7) are applicable when the end load is tension instead of compression if − P be written for P.

* Morley's Strength of Materials.

TINPLATE MANUFACTURE AND DETINNING.

IT s rather curious that the tinplate manufacture, which has long been centred in the United Kingdom, and in South Wales in particular, should not have originated in the Tin Islands, the name by which this country was known to the Phenicians. Yet it is considered a fact that, while the tinning of brass and copper was an ancient art, the tinning of sheet iron was introduced into this country from Germany, where it had been practised in Saxony and Bohemia before 1620. A Mr. Yarranton was sent over to Germany in 1670 to study the art, and tinplating works were started in Pontypool and worked successfully until E. Hemming obtained a patent for a rival process in 1691. Tinplating was, however, revived at Pontypool by John Hanbury in 1720, and there were four such works in Wales by 1750, this number being increased to 34 by 1850 and to 75 by 1875. Since then, we see from a paper on the "Tinplate Manufacture" which Dr. T. Lewis Bailey, F.I.C., recently read before the Society of Chemical Industry, the number of these works in Wales and Monmouthshire has not grown any further, but their capacity and output has much been increased.

Tinplate consists of sheet iron or mild steel which has been coated with a thin layer of metallic tin in order to prevent the oxidation and corrosion of the iron. The great impetus to the modern enlargement of the plating works is due to the growth of the industry of canning meat, fish, vegetables and fruit and to the universal demand for petroleum. Petroleum tins travel all over the world; the empty tins are valued, and the advance of civilisation along the great trade routes is sadly marked by the hideous shanties, built up of disused tins still with their gorgeously-coloured advertisements on them, which disfigure some settlements along the Suez Canal, in South Africa, America and in many other districts. A few years ago one-third of the exported tinplate was used for making petroleum cases, and our tinplating industry absorbed over 1,000,000 tons of steel and about 16,000 tons of tin. The production of tinplate in the United States, which has grown enormously during the last two decades, will hardly be smaller.

In the early days, when the physicist Réaumur described the process in 1725, inch bars were hammered out into sheet; the sheets were cut to size by hand, scrubbed with sand stone, pickled in fermented acid barley water for several days, dried, immersed in molten palm oil, and then transferred vertically to the bath of molten tin, brushed to remove an excess of tin, retinned in a second bath covered with molten tallow, and finally brushed and polished by hand with sawdust and moss. The resulting tinplate was of excellent quality, and the coating was thicker than is now deemed necessary.

Dr. Bailey, one of His Majesty's inspectors under the Alkali Act, described the modern tinplate process as of a totally different order. Machinery has largely replaced hand power, and the scale has been enormously increased, but the broad principles remain the same. Rolled bars, 6 in. to 10 in. wide, $\frac{3}{8}$ in. to $\frac{7}{8}$ in. thick, of low-carbon (0·1 per cent.) steel are cut by shears to length, usually of 20 in. The cut bars are heated and rolled hot; there are generally five separate heatings and rollings, and after the second (or first) rolling the bars are doubled, that is, two (or even three in America) and finally eight (or twelve) layers are rolled at the same time; a $\frac{3}{8}$-in. bar thus yields a sheet of eight layers, each a little over 0·01 in. thick. These rolled "eights" are sheared into three portions, so that the original 20 in. by 8 in. by $\frac{3}{8}$-in. bar will give 24 sheets of 14 in. by 20 in. The layers adhere to one another and have to be "opened," separated at one corner, and torn apart. Then follows the pickling; sulphuric acid was substituted 100 years ago for the hydrochloric acid, which had replaced the barley meal about 1760; from the waste pickle crystals of ferrous sulphate (copperas) are obtained. The sulphuric acid must not contain arsenic. Dr. Bailey speaks of electrolytic pickling as a novel American proposal. Trials of this process were made many years ago, however. The sheets to be pickled are loosely placed in carriers, dipped in the vat up and down for a few minutes, and then washed with water. The "black annealing" of the sheets, the next operation, takes 10 hours or 12 hours in coal or gas-fired luted furnaces in which the sheets are stacked horizontally; the black plates then pass cold through three or four trains of rolls, are annealed again for 8 hours (white annealing), and then smoothed; after another pickling in sulphuric acid for a short period they are ready for tinning. The tinning pots, containing 3 tons or 4 tons of tin, may be of the horizontal or of the vertical type. In either case the sheets enter the tin bath separately through a layer of zinc chloride, floating on the molten tin, and are guided down and up by pairs of rolls and guides, finally emerging vertically from a column of palm oil; during this latter stage the excess of tin is squeezed off by a pair of rolls. In the cleaning machine then the sheets are carried twice through a mass of bran or of "pink meal" (largely gypsum, mixed with sawdust sometimes) and delivered to a battery of dusting rolls covered with sheep skin, each alternate pair of rolls running at different speed to ensure polishing of the finished sheets. Modern tinplate carries about 1 per cent. of tin.

About the actual tinning process Dr. Bailey was not able to give particulars, but he referred at greater length to the chemical problem of dealing with the "dross" or "tin scruff" collecting at the surface of the tin pot. This scruff is a complex mixture of tin (50 per cent. about), tin and zinc chlorides ("flux skimmings" are rich in zinc chloride), iron and sulphur compounds, and palm oil, the latter more or less decomposed. The scruff is not sufficiently uniform for sale, and is heated at the works in reverberatory furnaces, yielding tin and metallic oxides which admit of sampling. The fumes from these furnaces form thick white fogs which, travelling to great distances, were so destructive to vegetation that they brought the scruff-smelting or liquation under the Alkali Act in 1906. Improvements have since been effected by the aid of depositing flues and wash towers; the legal nuisance has been stopped, but the tin losses still amount to 10 per cent., and the chemical and sanitary problems, to which we have referred in our comments on the Alkali Inspector's yearly reports, are not yet solved. The whole tinplating processes, it seems, might be improved; but these are questions for the practical expert. Palm oil answers quite as well as the tallow which used to be preferred. In old plants five pots in series were used, the first and last being the oil baths in which the temperature would not exceed 240 deg. C., whilst in one of the three tin pots it might rise to 400 deg. C.

Detinning had not until quite recently found a home in the centre of the tinplating industry, though the utilisation of tinplate waste goes back to 1846. Many processes were proposed and tried, also in this country, and about the beginning of this century electrolytic processes decidedly held the field. When the detinning problem was much discussed in 1908, because it became known that the firm of Goldschmidt, of Essen—of thermit fame—had given up electrolytic methods in their large detinning plant and had adopted a dry chlorine process, chemists and electrochemists over here, anxious to investigate the problem, experienced considerable difficulty in obtaining raw material for experimental purposes. There were detinning works over here, but not on a large scale; some of them prepared the waste metal for treatment without actually detinning it, and most of the tin scrap went over to Germany and Italy. Speaking on National Salvage last spring, Mr. David Currie estimated that some 150,000 tons of tinned steel were exported annually to Germany before the war. Detinning is an industry which can prosper only if conducted on a large scale. Apart from tinplate works themselves, the chief waste of tinplate occurs in canning establishments, far away from chemical works, as in Norway and Newfoundland, in the cigarette factories of Egypt, and all over the large business centres and towns, where the old cans go into the dust bin. The collection of that bulky, heavy material is in itself a business problem, and the most difficult task perhaps; the cleaning is another problem, and when it comes to detinning, we have to remember that the recovery of 1 per cent. of tin from iron scrap, over which the tin is spread almost in a film, will have to be carried out very judiciously to remain profitable.

In the laboratory detinning by electrolysis, as first tried by Nathaniel Keith, of New York, in 1876, is elegantly simple. The scrap is made anode in caustic soda, the tin dissolves as sodium stannate leaving a bright clean iron, and spongy tin is deposited on the iron kathode subsequently to be fused into block tin. When we have to deal with 50 lb. of scrap in wire baskets, things are very different. Unless the electrodes are fairly close together, much current is wasted; the introduction of the baskets cannot be effected with exclusion of the air and without absorption of carbon dioxide by the caustic soda, which is already deteriorated by impurities in the raw material, and finally a good deal of caustic soda adheres to the spongy tin and is lost. Well-detinned iron scrap is welcome to the steel maker, but iron with 0·2 per cent. of tin is not suitable for the Siemens-Martin furnace, and it is difficult not to leave patches of tin on the metal when electrolysing. These points made electrochemists look out for other methods, patents were taken out by the dozen, the caustic soda was replaced by sodium sulphide, &c., and some chemists fell back on the simplest method of dissolving the iron in hydrochloric or sulphuric acid, leaving the tin intact; iron salts, of course, have too low a value to make such a process commercially successful. Alkali electrolysis, however, indirectly came to the rescue of the detinning industry by supplying plenty of liquid and gaseous chlorine.

Chlorine dissolves tin forming the tetrachloride $SnCl_4$, known since 1605 as *liquor fumans Libavii*, a heavy fuming colourless liquid attacking the skin and the mucous membranes and very nasty to handle. When dry chlorine is passed over tinplate, the tetrachloride drips off, and the iron is not attacked. Higgins, in 1854, and others had tried that; but the fumes were too troublesome, and the iron was rapidly corroded when they washed off the liquid. To make the process independent of hand labour Lambotte, of Brussels, stacked bales of tinplate in a shaft furnace, introducing the scrap from above and the chlorine from below, and condensed the distilled tetrachloride. The vapours still gave trouble, however, and the iron rusted rapidly. The brothers Goldschmidt modified the process. They do not apply heat, because the action of chlorine on tin liberates 1,000 calories, and they draw the tetrachloride off from below. When Karl Goldschmidt described the process in 1908, they were dealing with 50,000 tons of scrap per year, ten other works in Germany working up about half that bulk; those figures have gone up considerably since.

In the Goldschmidt works the scrap is, or was, first flattened out between spiked rolls and perforated at the same time to facilitate cleaning and washing in alkali; the solder is then fused off in an oven, and the rubber washers are destroyed by heat. To apply heat before cleaning is inadvisable because the paper, glue, varnish and other organic matter are carbonised and burnt into the metal, preventing the subsequent solution of the tin. Bundles of compressed carefully-dried billets are enclosed in cases and stacked in a vertical iron cylinder, about 12 ft. high and 4 ft. diameter, into which chlorine is forced under a pressure of about 4 atmospheres. As long as the pressure in the cylinder continues to fall, the chlorine is still dissolving tin; when the gas pressure keeps constant, the reaction is completed; this is the criterion. The cylinder has to be cooled to moderate the reaction. A vacuum is then created under the furnace, and the tetrachloride is collected. The detinned iron is afterwards dropped into an evacuated vessel and possibly heated there to drive off all tetrachloride; then only alkaline water is admitted to wash the iron. A great deal depends upon this treatment of the iron which, though looking steel grey when taken out of the cylinder, may hopelessly rust in 24 hours. According to Goldschmidt this corrosion is due to the fact that dry chlorine does not attack the iron, but does attack the film of iron-tin alloy under the tin, unless the iron is washed after removal of all $SnCl_4$.

The chlorine process has since been applied or tried in many modifications, with what success is hardly

ascertainable. Goldschmidt dilutes his chlorine with air; sulphuryl chloride and other diluents have been used, Kügelgen has tried liquid chlorine, and Sperry works with centrifugal suction at 100 deg. Cent. for about an hour. Electrolytic processes are also being continued; they have the advantage that they yield metallic tin. The tetrachloride is, however, utilised as such in silk-dyeing, and in this way one more chemical industry is connected with the great artificial dye industry. Conditions are not propitious for the development of tin-waste reclamation in this country at present.

RECENT HARBOUR AND DOCK WORKS AT SINGAPORE, STRAITS SETTLEMENTS.

[(*Concluded from page* 670.)

King's Dock, Keppel Harbour.

As will be seen from the general plan, Fig. 1, published on page 603 *ante*, the King's Dock lies in Keppel Harbour, some distance to the westward of the "Empire Dock," which was described in our previous article. The nature of the site of the dock was generally similar to that of the Empire Dock, that is to say, it consisted of mud overlying clays and shale.

The greater part of the area was covered by water at high tide, so that the first operation was to dry the site. For this purpose, a water-tight embankment was run out from the shore some little distance to the eastward of and parallel to the dock, until the low-water line was passed. The bank consisted of laterite deposited on either side of a centre row of sheet piling, the latter being driven well down through the mud into the underlying stratum. In continuation of this bank, a cofferdam, consisting of a double row of sheet piling, filled in between with clay puddle, was driven, enclosing the seaward end of the dock and joining in with the existing reclamation to the westward. The cofferdam was supported by a rubble mound on the outside and a mound of laterite on the inside. The position of this cofferdam is shown in Fig. 43, on Plate I., published with the present issue.

As soon as the watertight embankment and dam were closed, the area within was cleared of water, and excavation commenced. A certain amount of material was first removed over the whole area of the dock, so as to reduce the depth of the trenches, except at the head of the dock, where they were carried down from the original surface. As the side walls were completed, the dumpling between was removed by means of timbered cross-trenches, alternate trenches being first excavated and concreted, the intermediate lengths being subsequently dealt with. The work was founded throughout on the solid shale.

A longitudinal section and general plan of the dock are shown on Figs. 42 and 43. It will be seen that the dock is provided with an inner and outer entrance with wing walls extending into the channel, forming a bell-mouthed approach. In the eastern wing wall a recess is provided forming a berth in which one of the caissons can lie when not in use. The overall length of the dock inside the entrance at coping level is 852 ft., but it will be noticed that a stop is provided outside the outer caisson groove, by the use of which the available length of the dock can be increased by 16 ft. 6 in. It will further be noticed that by means of the centre caisson, the dock is divided into two lengths, of 486 ft. and 325 ft. respectively, when the caisson is in place. The width of the entrance at cope level is 100 ft., the walls being built to a batter of 1 in 12. The depth of water over the cill of the outer entrance, and over the top of the keel blocks is 25 ft. at L.W.O.S.T., or 34 ft. at H.W.O.S.T. The level of the cill of the inner entrance is placed at 28 ft. below low water.

The wing walls were carried out, so far as it was possible, in timbered trenches inside the cofferdam, in a manner similar to that adopted in the case of the side walls of the dock. As soon as the works inside the dam were completed to the full extent possible, the cofferdam was removed, and the remaining lengths of the wing walls were carried out in concrete blockwork deposited through the water in the same manner as was described in our previous article, for the blockwork walls of the wharf reconstruction at Tanjong Pagar.

The material derived from the excavations was used for filling up and raising the general area of the ground around the dock to the level shown on the cross-sections given in Figs. 44 to 46. These cross-sections clearly show the general features of the dock. The walls and floor consist of Portland cement concrete. Near the bottom of the walls are a series of small altar steps, above which are the main altars, for general shoring purposes. The altars and the altar facing are formed of small concrete blocks moulded to the shapes and dimensions required. Flights of granite steps leading to these altars are provided at each end, and in the middle of the dock. These clearly show in Figs. 42, 45, and 46. The walls throughout are surmounted by a granite coping. Three rows of granite blocks are laid longitudinally throughout the length of the floor in the positions shown, so as to provide a seating for the keel blocks.

The emptying culvert for the inner dock is carried through the body of the west wall, as shown on Section A A, Fig. 45, and thence to the pumping station; the corresponding culvert for the outer dock is carried directly across from that dock, as indicated on the general plan, Fig. 43, where the two culverts are clearly shown. Filling culverts are provided in each wall at both the inner and outer entrance, as shown.

Figs. 47 to 50 give particulars of the outer and inner entrances. It will be seen that the walls and cills are faced with granite. Caisson grooves formed of the same material are provided at both entrances for working the caissons, the outer entrance being further provided with a stop, as already described. The working faces of the grooves and stop were all carefully dressed and fine axed, so as to produce a true and even surface, in order that a perfectly water-tight joint might be formed between the masonry and the timber meeting faces of the caisson when the latter is in position. On Fig. 50 is shown the inlet to the emptying culvert, formed in the dock floor, which has already been referred to. The culverts are provided with cast-iron penstocks, having gunmetal working faces, the sluice doors being raised and lowered by electric motors, the current for which is obtained from the Board's generating station.

A short distance inside the outer entrance and adjoining the west wall of the dock, is the pumping station, as will be seen from the general plan, Fig. 43. Details of the pumping station are shown in Figs. 52 to 54. The foundations of the engine-house consist of Portland cement concrete carried well down into the shale. The two emptying culverts, to which reference has already been made, are led into a main sump running the whole length of the engine house, and formed in the concrete base, as shown on the plan and section A A, Figs. 52 and 54. The centre of the engine-house is in the form of a deep well, in which the pumps are placed, the pump suctions being carried down through the concrete into the main sump, in the manner shown in Fig. 54. An asphalte damp-course is provided below the floor of the engine-house, and continued up the back of the walls, so as to prevent the moisture percolating into the well, for it will be noticed that the floor of the well is considerably below the level of low water. The face of the well is lined with white glazed brick, for cleanliness, and also to give light.

The discharges from the pumps are formed of cast-iron segments, built into the concrete. As will be seen from the plan, Fig. 52, they lead from the pumps into a chamber situated immediately outside the engine-house, the discharge outlets into this chamber being provided with non-return valves. A large culvert is laid from the further side of this chamber, which finally discharges into the harbour outside the outer entrance through the western-wing wall. The general arrangement of these culverts are clearly shown on the plan, Fig. 43. Between the two main pumps are a pair of drainage pumps with suction and discharge pipes, all as shown on the plan and sections, Figs. 52 to 54.

The pumps themselves were supplied by Messrs. J. and H. Gwynne and Co., of Hammersmith. The main pumps consisted of two "Invincible" centrifugal pumps, having double suction pipes 42 in. diameter, and single discharge pipes, 60 in. diameter, driven by vertical direct-acting compound engines, working at 150-lbs. pressure. The capacity of the dock at high water is about 3,570,000 cub. ft., the total lift from the dock bottom at high water being about 39 ft. It was required of the pumps that they should together be capable of emptying the dock in three hours. As a matter of fact, at the time of the trials, this was accomplished in less than two hours. Each pump is provided on the discharge side with a sluice valve actuated by an electric motor, these sluices being in addition to the non-return valves already referred to. For drainage purposes, two 12-in. centrifugal pumps are used, each being capable of delivering 2,500 galls. per minute against a head of 50 ft. of water. These pumps are driven by electric motors.

Immediately adjoining the engine-house is the boiler-house. In order to save expense in foundations, this building is carried throughout upon bearing piles driven down to the shale, the general arrangement being shown on Figs. 52 and 54. Three Babcock and Wilcox water-tube boilers of the land type have been provided, and space is left in the boiler-house for another set if this should be required hereafter. The working boiler pressure is 160 lbs. Superheaters and an oil eliminator are also provided. In connection with the boilers, an induced-draught plant has been introduced, consisting of a centrifugal fan driven by electric motor, placed in the flue between the boilers and the chimney shaft. By this means, considerable expense in the construction of a large chimney shaft has been avoided.

In Figs. 55 to 59, on page 703, are given general views and details of the caissons used for closing the dock entrances. Two caissons have been provided. As will be seen from the drawings, they consist of steel plating supported by angle-steel frames, these being stiffened and strutted as required, and as shown in the cross-section, Fig. 55. Two water-tight decks, marked deck "C" and deck "D," are provided, as shown, the space between the two decks forming the air chamber. In the lower chamber, that is, between deck "D" and the keel, is placed the ballast, the trim being so arranged that when afloat deck "C" shall be slightly above water level. Above deck "C" are three water chambers, divided from one another by two water-tight bulkheads. Immediately below the upper deck is the top water or ballast tank, while a second tank, called a "scuttle tank," for use in emergencies, or to enable the caissons to be more rapidly sunk than would be the case when using the upper ballast tank alone, is provided below deck "D." When about to be used, the caisson is floated into position at either entrance. The top water tank is then filled, the effect being to sink the caisson sufficiently to allow the water to run into the chambers above the water-tight deck, thus causing the caisson to sink finally into its place. The trim of the caisson, whilst sinking can be adjusted by means of valves which regulate the entry of the water into the three water chambers.

The top surface of each caisson is decked over to form a roadway, being also provided with rails for railway traffic. The caissons were constructed by the Thames Ironworks and Shipbuilding Company, being first erected at their yard at Blackwall, after which they were taken apart and shipped to Singapore, where they were re-erected on the floor of the graving dock, prior to the removal of the cofferdam. Greenheart timbers were bolted to either side of the stems and keel, being planed perfectly true and even, so as to form a watertight joint with the masonry of the grooves and stop. A section of the keel showing the greenheart is given on Fig. 58.

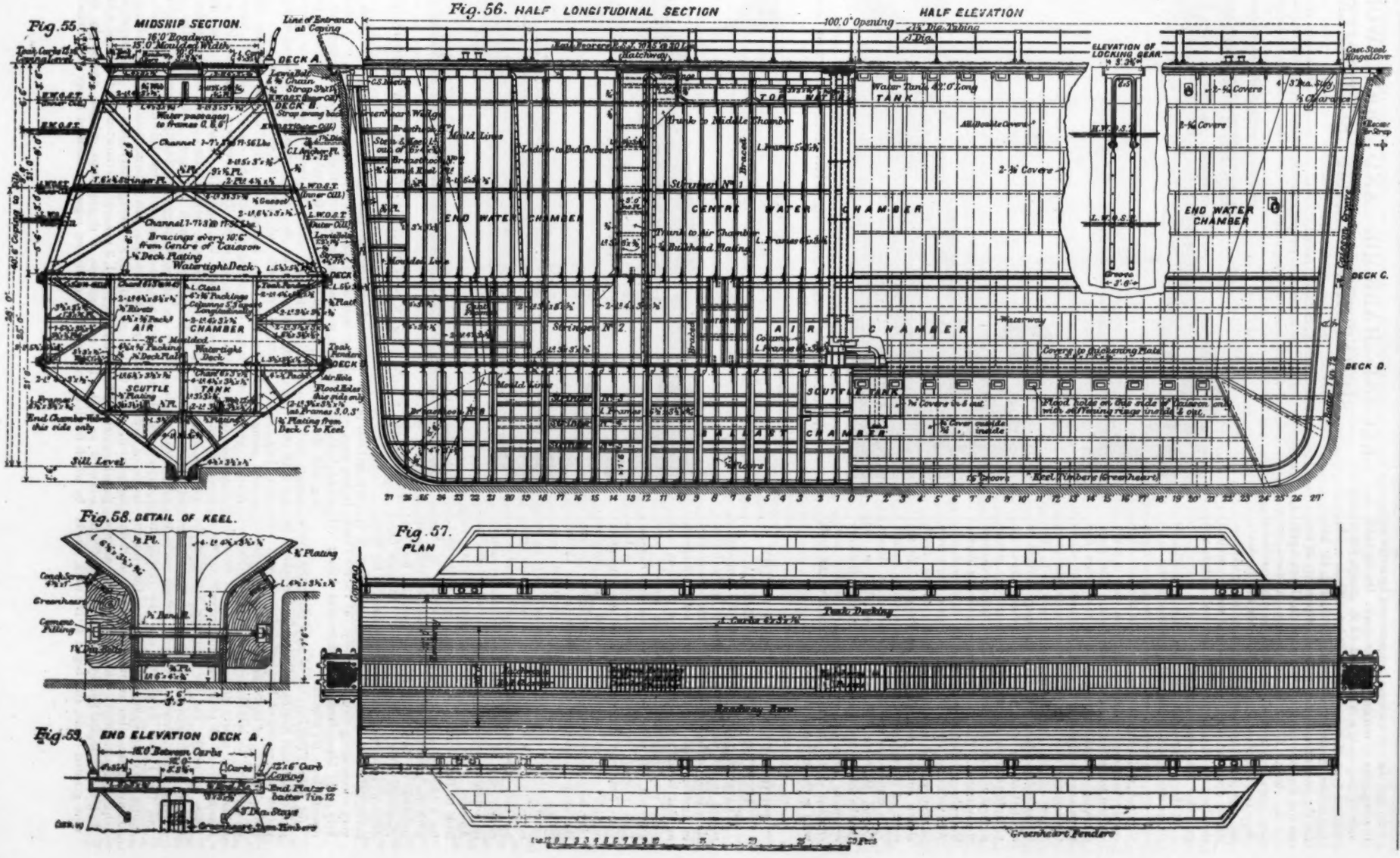
When the first caisson was completed, the water was temporarily let into the dock, in order that the caisson might be floated into position in the outer groove. After this had been done, the water was again pumped out, so that the second caisson could be erected, the first caisson meantime acting as a dam, so as to enable the cofferdam to be removed, and the guide walls, dredging and entrance work generally to be completed.

Provision was made on the west side of the dock for a powerful travelling crane, capable of lifting 50 tons, having a gauge of 26 ft., the inner wheels running upon rails let into the coping of the dock

HARBOUR AND DOCK WORKS AT SINGAPORE; FLOATING CAISSON FOR KING'S DOCK, KEPPEL HARBOUR.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, AND MR. J. R. NICHOLSON, M.M.INST.C.E., ENGINEERS.

(*For Description, see opposite Page.*)



wall, and the outer wheels being carried by a row of bearing piles driven down to the shale. On the east side of the dock a crane road 13 ft. gauge, for a smaller type of crane was provided. These roads are shown on the cross-section B, B, Fig. 46, but for the present a 15-ton crane is temporarily in use on the west side, and a 5-ton crane on the east side of the dock. Eight 11-ton electric capstans are also provided around the dock in the positions shown on the plan, Fig. 43. Bollards and fairleads are also placed where required, these being likewise shown upon the plan. The general surface around the dock was finally metalled and well rolled, and provided with open drains.

Of the photographic views on page 714, Fig. 60 shows one of the caissons in position at the outer entrance, the second caisson being seen floating in the dock, while Fig. 61 gives a view of the dock when empty, and nearly completed. This view is taken looking towards the head of the dock. The inner entrance and the arrangement of the altars and steps are clearly shown. Fig. 62, annexed, shows the western side of the outer entrance, the inner groove and the stop being clearly indicated. The filling culvert is also shown, the large culvert on the left of the view being the discharge from the pumping station. Fig. 63, on the present page, gives a general view of the dock when filled, looking towards the entrance. The inner entrance is clearly shown, the caisson being in position at the outer entrance. A little to the left of the outer entrance, the second caisson will be seen floating in the caisson berth shown on the plan, Fig. 43, on Plate L. To the right of the entrance is shown the pumping station.

In conclusion we desire to express to Messrs. Coode, Matthews, Fitzmaurice, and Wilson our thanks for having placed at our disposal the very complete drawings and particulars which have enabled us to describe the important works dealt with in the foregoing article.

PRODUCTION OF POTASH IN THE UNITED STATES OF AMERICA.

Whatever may be the position of Germany in regard to the world's potash supply in the future there is no doubt that the problem has been tackled in America with the same energy and enthusiasm as that brought to bear on the dyes problem, and some very important results have already been achieved. So much is this the case that Senator Lane recently expressed the opinion that in two years from now America would be independent of outside sources of supply. What this implies may be gathered from the fact that before the war the annual consumption of potash in the United States of America was over 1,000,000 tons, practically all of which was imported. It is to be hoped that this optimistic forecast will prove true, for the question of adequate potash supplies is clearly one of great and far-reaching economic importance, especially in the United States of America. The world will undoubtedly have to look to that country for a great part of its food, for a time, at all events, and the ability to cope with this great task will largely depend on sufficient supplies of fertilisers, notably potash, for the American wheat and cotton fields. At least four different sources of potash supply have so far been investigated in America, and all of them with very encouraging results, namely, (*a*) Pacific Coast kelp; (*b*) blast furnaces and cement kilns; (*c*) desert lakes; (*d*) alunite.

(*a*) *Kelp.*—The burning of kelp along the coasts of Scotland and Northern France for the sake of its potash was practised hundreds of years ago, but the opening up of the Stassfurt deposits practically doomed this old-established and fairly considerable industry. It nearly died out altogether until the soaring prices of potash again revived it. Some years before the war the arbitrary action of the German Government in forcing Americans who had purchased an interest in German potash works to join the Potash Syndicate, and the subsequent course of events, induced the American Government to investigate other sources of potash, including kelp, felspar, desert lakes, leucite and alunite. Both the Geological Survey and the Bureau of Soils were granted funds, and began active work which, even in 1914, proved already of considerable value. It was soon realised that potash could not be produced from all of these at pre-war prices without the aid of by-products, and in some cases the potash itself would be the by-product. This, as we shall see, has already proved to be the case with kelp. These enormous deposits of kelp extend along the Pacific Coast from Mexico to Alaska, and several large companies are now engaged in harvesting and treating the kelp. The first attempts were somewhat crude, but subsequently large and properly equipped power harvesters were employed, provided with a mechanical reaping device and band conveyors, by means of which the kelp was discharged into hoppers, thence into dryers where it was partly incinerated, and finally ground. The average potash content of Californian kelp is 1·3 per cent., reckoned as K_2O. The mere process of drying, by which fertiliser only is obtained without regard to any of the other valuable products contained in kelp is, of course, only feasible with the present high prices. Developments have more recently taken another direction, the main object being the production of fine chemicals, with potash as a by-product, and instead of drying the kelp fermentation is resorted to.

In 1915 the Hercules Powder Company began the construction of large petrol-driven kelp harvesters, and installed a plant at San Diego, in California, for the production of acetone, iodine, &c., as the main products. The old process of drying the kelp had presented difficulty owing to its cellular or vascular structure, but this difficulty does not, of course, arise with fermentation. The kelp is conveyed from the harvesters to the fermenting vats where it is fermented and the acetic acid produced is converted into calcium acetate by addition of lime. The fermented liquor now contains in solution calcium

RECENT HARBOUR AND DOCK WORKS AT SINGAPORE, STRAITS SETTLEMENTS.

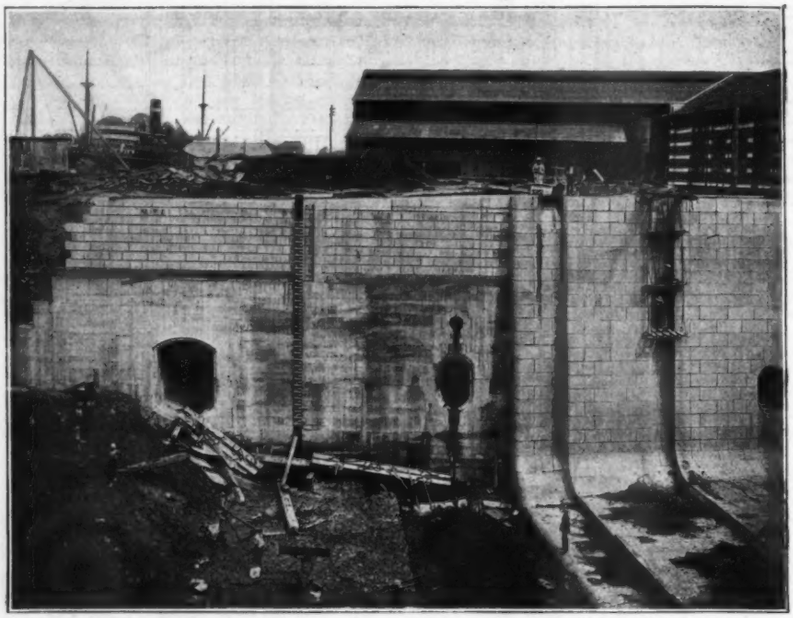


Fig. 62. King's Dock, Keppel Harbour; Entrance during Construction.

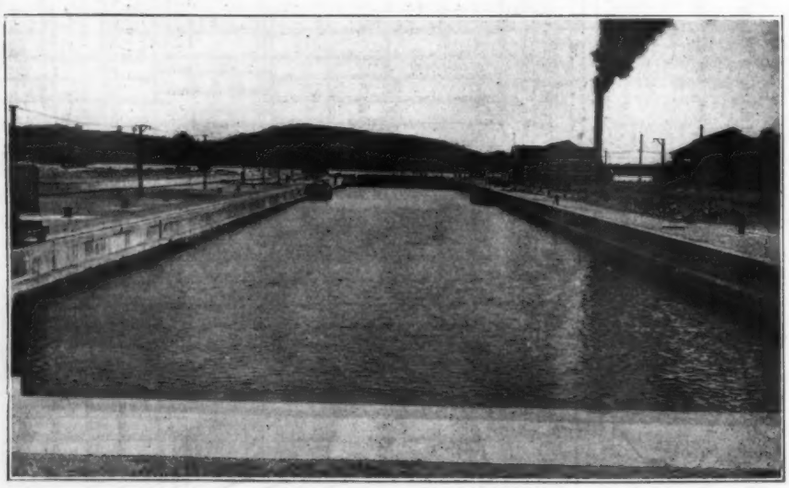


Fig. 63. King's Dock, Keppel Harbour; General View looking towards Entrance.

acetate, potash and iodides, and after evaporation and concentration yields three intermediates: (1) This consists of a mixture of calcium acetate and potassium chloride which, when heated in ordinary acetone retorts, yields acetone and carbonate of lime with unchanged potassium chloride; (2) calcium salts of the higher fatty acids which, by treatment with alcohol and sulphuric acid, yield the corresponding esters which are easily separated by fractionation into ethyl-acetate, -propionate and -butyrate; (3) consisting chiefly of potassium iodide, which is treated with chlorine and the precipitated iodine is dried and resublimed. In addition to the foregoing products it is also hoped to obtain algin, which may ultimately become a valuable commercial product, also ammonia, and valeric and caproic acids. In this way it is anticipated that a great industry for the manufacture of fine chemicals from kelp will be developed, and that large supplies of potash will result as a valuable by-product.

(2) *Blast Furnaces and Cement Kilns.*—The recovery of potash from flue gases and from cement kilns is of particular interest to engineers. It not only furnishes a very good illustration of the electrostatic precipitation or separation of materials (liquid or solid) from gases holding them in suspension, but it also exemplifies the valuable results which may follow from purely scientific research undertaken without any particular reference to industrial application. The Cottrell process of electrostatic precipitation, for instance, is undoubtedly based on the experiments carried out by Sir Oliver Lodge in 1885. In 1906, Professor Cottrell of Berkely University, California, introduced his now well-known precipitation process, which in this case was applied to the removal of sulphuric acid mist from the gases of a contact plant at Mannheim. Since that date the process has been successfully used in numerous smelting works in America—and also in this country. In 1911 it was installed at the Riverside Portland Cement Works in California in order to deal with the dust nuisance. The precipitator in this plant consists of a lead-lined chamber in which lead plates are suspended as receiving electrodes, whilst lead-covered iron rods fitted with asbestos or mica handles serve as discharge electrodes. In other plants a pipe and chain type of precipitator may be used. In this type the receiving electrode consists of a 16-ft. pipe in which a chain suspended axially acts as discharge electrode. The potash recovered from the dust in the above-mentioned Californian cement works has more than paid for the initial cost of the installation.

In 1912 the Research Corporation of New York began to develop the Cottrell process, and applied it to various works in the eastern United States. A visit was paid to one of the plants of the Bethlehem Steel Company, and an analysis made of the flue gases there and also at other blast furnaces. As a result of numerous investigations of this kind it was confirmed—what had already been anticipated—that, whilst some iron ores contain no potash at all, others contain as much as 3 per cent. This latter percentage is found more especially in the Alabama ores of 48 per cent. to 52 per cent. iron content. These ores are favourably situated and yield good iron at low cost. The potash in them acts as a desulphuriser, thus improving the quality of the iron. In addition to iron ores, fluxes and cokes and dolomites were also examined, many of them containing appreciable percentages of potash. Cambrian potash-bearing slates and sericites have been discovered in Georgia containing up to 8 per cent. or 9 per cent. of potash obtainable by volatilisation in a rotary kiln. The addition of common salt to the extent of 200 lb. or 300 lb. per ton of raw material is found to be an effectual aid in the recovery of water-soluble potash. In all these cases the Cottrell process has given excellent results. The statement has been made that if all the furnaces in the United States dealt with potash-containing ores the amount of potash that could be recovered in this way would be in the neighbourhood of 1,500,000 tons annually. This must, of course, be largely discounted owing to the fact that all the ores do not contain potash.

A survey of the cement plants carried out by the Bureau of Soils shows that the cement industry could furnish up to 100,000 tons of potash annually if high percentage potash material is used, such as feldspar, sericite and Cambrian slate. The Riverside Portland Cement Works, previously referred to, had spent over 1,000,000 dols. in lawsuits, purchase of orange groves exposed to the fumes, and various attempts at dust collection. After thoroughly investigating the Cottrell process the company decided to put in an installation capable of dealing with the gases from 10 rotary kilns, the volume being 1,000,000 cub. ft. per minute, and the temperature 400 deg. to 500 deg. C. The efficiency was at first 95 per cent., the dust collected amounting to nearly 100 tons per 24 hours. The discharge electrodes were wire, and the receiving electrodes consisted of built-up wire screens. A year or two ago a pipe and chain type of precipitator was added and the recovery has risen to 99 per cent. This installation has been working since 1913, and has proved a very good investment.

(c) *Desert Lakes.*—One of the most interesting of these lakes from a potash point of view is Searles Lake, in California. This so-called lake consists of a vast agglomeration of crystals, chiefly of sodium chloride (common salt) resulting from the evaporation of a prehistoric lake. A full description of the lake is given in Bulletin 580L issued by the United States Geological Survey, from which the following particulars are taken:—

"The area of salt crust in the Searles Basin is some 12 sq. miles in extent, and averages from 65 ft. to 75 ft. in depth. The formation of the crystal body is such that the brine with which it is associated is absolutely free-flowing, and nowhere, even by extended pumping operations, has it been possible to lower the level of the brine in the lake at any one spot to a noticeable extent.

"The main or central salt deposit is a firm but extremely porous bed of salt crystals so hard and compact that roads are made on it, teams and motor trucks are driven over its surface, and even the concrete foundations of the American Trona Corporation's pump house were laid on the surface. "The first 15 ft. to 20 ft. of the crystal body is composed of cubical halite and analyses 90 per cent. or more NaCl dry basis. Below this are alternating and irregular layers of salts respectively high in trona (sesqui-carbonate of soda), sodium chloride and sodium sulphate. The average potash content of the crystal body is 4 per cent. KCl. It is estimated that the crystal body contains 594,000,000 tons of brine capable of yielding 23,760,000 tons of KCl (potassium chloride)."

The brine is pumped to the Trona Corporation's plant from wells drilled in the crystal body. It is pumped into storage tanks, thence to the evaporators passing through a 16-ft. Manistee vacuum pan which is used merely as a preheater. It is then pumped to three 22-ft. pans of the same type operated in triple effect. These pans handle from 200,000 gallons to 250,000 gallons of raw brine and about 100,000 gallons of mother liquor per 24 hours. The whole is concentrated down to about 100,000 gallons and sent to the crystallising house to cool. During the boiling sodium-chloride, -sulphate, and -carbonate are salted out, dropping to the bottom of the vacuum pans and removed by salt elevators of the regular Manistee type. The elevators discharge their salts into waste salt cones from which they are washed away by water. Machinery has now been installed to recover the potash from this waste water, thus increasing the potash production by at least 10 tons of KCl per unit per 24 hours.

The American Trona Corporation is producing about 4,500 tons crude potash salts per month with the additional equipment recently installed. By the beginning of 1919 they hope also to obtain about 50 tons of refined borax per day. A raised road has been built completely across the lake, connecting the Trona Railroad with its Trona claims by a narrow-gauge petrol-worked railroad.

Attempts are also being made to exploit the Great Salt Lake for its potash, *e.g.*, by the Diamond Match Company, and the Virginia Carolina Chemical Company, in co-operation with the Inland Crystal Salt Company of Salt Lake City, and other lakes, but the very large amount of evaporation required is a very considerable drawback.

(d) *Alunite, &c.*—This mineral has been mined in Italy and Smyrna for centuries for the production of potash alum. A few years ago deposits were found near Marysvale, in Southern Utah, U.S.A., and in 1915 the Mineral Products Corporation built a plant for the recovery of potash from alunite. This plant has been in continuous and successful operation for three years, with the exception of one or two shut-downs owing to fires. The output is about 600 tons per month of high-grade potassium sulphate. As alunite is a double sulphate of potassium and aluminium it is hoped ultimately to obtain aluminium salts in addition to the potash, the same as is now being attempted with mineral silicates such as feldspar and sericite. Meantime several methods have been proposed for obtaining the potassium salt. The simplest probably is that used at the above plant where the ore is calcined at about 1,000 deg. C., whereby the crystallisation water and sulphuric acid are driven off, leaving potassium sulphate and alumina. The solution is leached and evaporated. The raw material used by the Mineral Products Corporation is nearly pure alunite, but other deposits in the neighbourhood contain more silica, which appears to interfere with the calcination and subsequent refining of the alumina. The silica content may be reduced, however, by calcination with producer gas instead of pulverised coal and separation of the alumina by flotation. The potash content is about 10 per cent. as K_2O or 18 per cent. to 20 per cent. as sulphate. By gradual improvements in the plant it is hoped to be able to compete with the potash from Central Europe even in normal times.

As is well known, numerous attempts have been made and patents taken out for the manufacture of potash salts from silicates such as sericite and orthoclase (feldspar). One of the most interesting of these is that described by Frazer and others in the *Jnl. of Ind. and Eng. Chem.*, 1917, vol. ix, pages 935 and 936, in which the feldspar is first converted into a substance analogous to leucite by treatment with alkali. Potassium chloride and aluminium sulphate are subsequently obtained by suitable treatment with acids, thus avoiding the troublesome and expensive operations of evaporation, crystallisation, &c. It is even suggested that this may prove a better source of aluminium than bauxite.

It may appear at first sight that the location of most of the potash sources in the far West, remote from consuming centres, is a rather serious drawback. But this does not entirely apply to blast furnaces and cement kilns, perhaps the most promising source of all, and in any case none of them is so remote as Germany. The U.S. Government also is controlling freight charges with a firm hand, and already Armour and Co. have successfully claimed rebate of about £520 from the Denver and Rio Grande R. R. and Co. et al. for overcharge on carriage of potash from Marysvale, Utah, to New Orleans. The chief competitor will probably not be Europe (Germany or Spain) but Chili, where serious attempts are being made to obtain potash from the nitrate fields.

In regard to Spain, something of a sensation has been created in American circles through the reported collusion of the Spanish Government with the German Kali (Potash) Syndicate with a view to blocking French and Belgian interests in the Barcelona deposits.

KING'S COLLEGE, LONDON.—After a break of four years on account of the war, the Engineering Society of this College held its 21st dinner at the Trocadero Restaurant on Friday the 6th inst., Mr. C. H. Wordingham, C.B.E., F.K.C., M.Inst.C.E., President of the Institution of Electrical Engineers, being in the chair. Principal R. M. Burrows gave an account of the work done by the Engineering Department during the war. Dealing first with the problem of the education of refugee students, he described the work carried out for the Ministry of Munitions in the training of those engaged on the production of aeroplane parts—no less than 1,200 having passed through. The Aeronautical Inspection Department had been supplied by the College with 400 inspectors whose training had been there supervised. The Department of Engineering had also been responsible for important work in connection with the geological survey, the Ministry of Munitions Optical and Glass ware supply, and the Research Committee of the Institution of Electrical Engineers.

BOWTELL LUFFING CRANE.

The illustrations on this and the opposite page show one of the latest and most efficient types of level luffing crane, made by Messrs. Ransomes and Rapier, Limited, Ipswich. The design is exceedingly simple, the level path being obtained by the automatic paying-out or taking-in of the load rope during the operations of luffing in and luffing out respectively. The crane frame and the jib follow the lines of ordinary crane design, nothing very special being necessary.

The load rope in its passage from the jib head to the barrel, passes first round a pulley A (Fig. 1) at the jib foot, thence round a pulley B movable along the front member of the crane frame, then round another pulley C at the jib foot, and then to the barrel. The pulley which moves on the front member of the crane frame is connected with the luffing gear in such a way that as the jib is luffed in the pulley moves towards the jib foot, and when the jib is luffed out the pulley moves away from the jib foot, thus paying out or taking in the load rope.

An important feature is that the portion of the rope from the jib foot to the jib head does not alter in length during the operation of luffing. The amount of load rope paid out or taken in through the movement of the travelling pulley is equal to the vertical rise or fall of the jib head and consequently the movement of the pulley is always in sympathy with and compensates for the vertical movement of the jib. As the pulley is in a bight of the load rope it will be seen also that its movement is half that of the lifting hook, and is consequently equal to the vertical movement of the centre of the jib. The weight of the pulley, together with that of runners or carriage upon which it is mounted, is made such that the jib is balanced against gravity in any position.

The moving counterbalance on the crane shown is constructed of two large rolling weights running upon rails attached to the crane frame and carried by small axles; it is therefore practically frictionless and noiseless. The member of the crane frame upon which the counterbalance travels is inclined backwards from the jib foot so that not only is the jib balanced against gravity but its moment about the jib foot is also partially balanced.

In the design shown on Fig. 1, the luffing gear is placed at the top of the inclined member. The luffing rope and the rope controlling the moving counterbalance are wound on to barrels connected together and mounted upon the same spindle, and the luffing rope is taken direct from its barrel to the jib head. One of the barrels is fuseed, thus giving a horizontal path to the load. Should a path other than horizontal be required, *i.e.*, the load gradually falling or rising when luffing in or out, this can be obtained by adjustment of the fusee barrel. If the luffing rope is taken from its barrel round a pulley D (Fig. 2), supported on the frame in front of the inclined member, instead of direct to the jib head, the pull on the luffing rope is constant with any inclination of the jib and consequently no fuseeing of the barrel is necessary.

An important point in connection with the luffing gear, although it has no bearing upon the level luffing feature, is the hanging of the worm gear and the motor from the barrel spindle, the motor itself being attached to members fixed to the worm gear casing and connected to the crane frame by means of links. By this arrangement deflection of the crane frame produces no extra stresses upon the worm gearing which would be the case if the motor were rigidly attached to the crane frame.

From the fact that the luffing gear is placed at the top of the crane frame, above the house, and that the load rope passes round a pulley at the jib foot, it is possible to construct a house which is completely closed during operation with the exception of a hole 6 in. square at the jib foot for the passage of the load rope. This is a very important point in connection with wharf cranes which have to be operated under all weather conditions.

Fig. 3 shows one of the six cranes supplied to the War Office. These cranes lift 5 tons at 80 ft. per minute, slew at the rate of 1½ r.p.m., and travel at 60 ft. per minute. The maximum radius is 42 ft. and the minimum 20 ft. The speed of luffing measured on the horizontal is 150 ft. per minute; the time for the complete range of luffing being 8·8 seconds. The luffing gear is operated by a weather-proof motor of 6·5 h.p.

Fig. 1 shows a design of crane having a range of radius from 105 ft. maximum to 25 ft. minimum. Fig. 2 shows part of a crane of similar duty but with the luffing rope taken round a pulley on a vertical frame obviating the use of a fusee barrel.

THE BOWTELL PATENT LUFFING CRANE.

CONSTRUCTED BY MESSRS. RANSOMES AND RAPIER, LIMITED, IPSWICH.

Fig. 1.

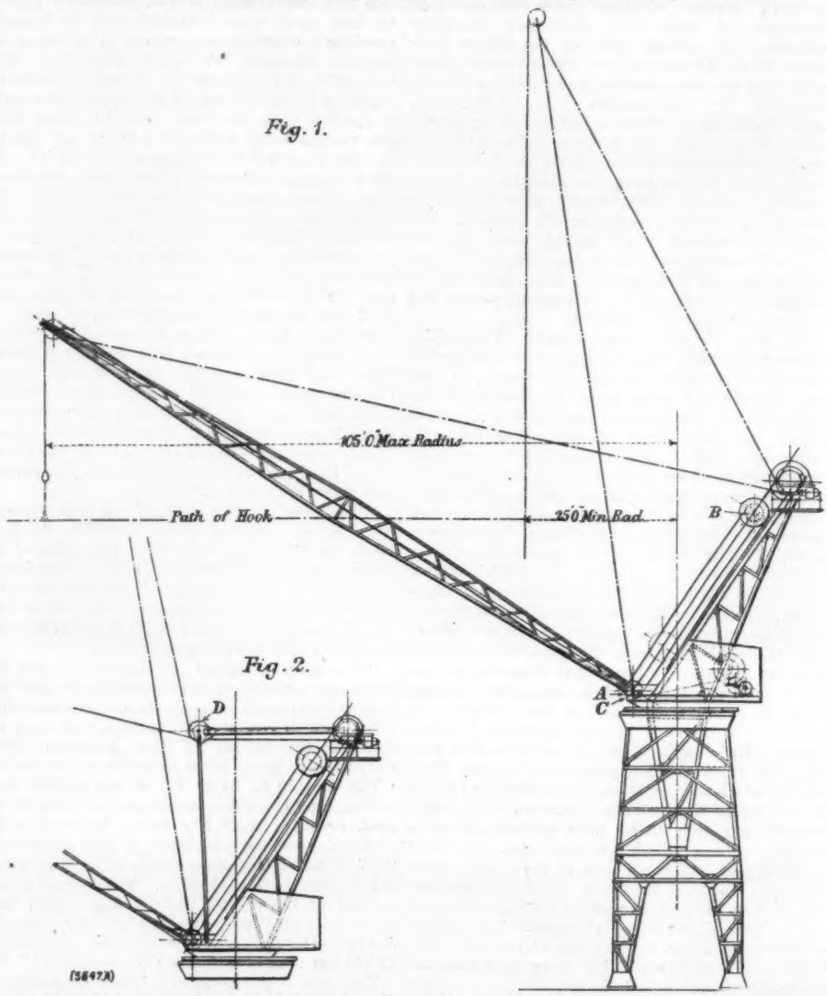


Fig. 2.

Shellac.—In reference to The Shellac Control Order, 1918, made by the Minister of Munitions, and dated March 12, 1918, the Minister of Munitions hereby orders as follows:—(1) As from the 10th inst. the said Order is revoked. (2) Such revocation shall not affect the previous operation of the said Order or the validity of any action taken thereunder or the liability to any penalty or punishment in respect of any contravention or failure to comply with the said Order prior to such revocation, or any proceeding or remedy in respect of such penalty or punishment.

Spectroscopic Determination of Lead in Copper.—A spectroscopic quantitative lead test, for use in copper refineries, was proposed by C. W. Hill and G. P. Luckey before the April meeting of the American Electrochemical Society. Once set up the apparatus seems to admit of rapid tests of a fair degree of accuracy. A small pellet of the copper from the ladle, such as used also for chemical analysis, is placed in the graphite cup of a vertical arc; both the electroides are rotated by a motor. As soon as the copper melts a lead line appears in the violet of the spectrum next to a copper line; the observer determines with the aid of a stop watch the interval between the appearance and the disappearance of the lead line. That interval will increase with the lead percentage, and range, *e.g.*, from about 20 seconds for 0·001 per cent. to 230 seconds for 0·05 per cent. of lead. There is, of course, a personal error in all spectroscopic work of this kind, and there are other limitations of a test. Pellets or shot of the small weight of 0·3 gramme or 0·4 gramme have to be used; with heavier samples the time test might be misleading, and the small sample necessitates very careful weighing and presumes a very uniform distribution of the lead through the copper. Further, the arc must be very steady, and the heating not too rapid lest some of the metal be thrown out of the electrode cup. There might also be segregation during the preparation of the shot from the ladle. On the other hand the usual electrolytic test (dissolving the copper in nitric acid and precipitating the lead as peroxide) is not more reliable than the new test suggested, because the precipitation is apt to be incomplete, and Hill and Luckey found the spectroscopic test fairly reliable even for copper samples impregnated with up to 0·3 per cent. of lead, which should be quite abnormal for refinery practice.

The German Steel Union.—Some changes have recently been made in the allotment of the various works belonging to the Union, the result being a reduction in the production of billets at certain works. The aggregate reduction amounts to some 47,000 tons, which fall upon the Lorraine iron works, the Gute Hoffnungs Hütte and the German-Luxemburg Company. The following complete list of allotments may be of interest:—

Names of the Works.	Billets.	Railway Material	Plates and Shapes.
Gelsenkirchen	100,081	107,630	167,858
Hoesch	—	84,611	86,379
Deutscher Kaiser	51,75	213,670	191,691
Hasper	13,000	—	42,883
Gute Hoffnungs Hütte	13,098	84,169	66,911
Phœnix	134,396	4,896	11,164
Rhenish Steel Works	73,099	1 .272	52,108
Krupp	159,567	252 595	73,887
German Luxemburg	73,099	221,452	244,179
Bochum Union	50,651	152,852	2,000
Vander Zypen	7,304	5,999	25,953
Georg Marien Hütt	500	90,000	—
Peine	—	6,776	201,510
Burbach Concern	190,834	145.468	233,672
Rechling	18,324	74.696	168,849
Stumm Brothers	38,676	93,550	130,242
Dillingen	42,760	61,249	—
Rombach	150,000	67,292	104,675
Lorraine Concern	97,578	54,906	93,512
Maximillians Hütte	5,000	88,748	83,746
Könen	1,138	25,500	—
Laura Hütte		60,600	34,000
Friedens Hütte	—	90,764	138,571

According to the arrangement arrived at in October, 1918, the Union now remains in force until June 30, 1919. The most important alterations which have taken place in the matter of allotments during the war refer to the severance of the de Wendel Hayingen Works (346,200 tons, complete allotment) through compulsory liquidation, and of the Société Ougrée-Marihaye, Rodingen Section, Luxemburg (117,765 tons, complete allotment) through the closing of the Rodingen Works.

THE BOWTELL PATENT LUFFING CRANE.

CONSTRUCTED BY MESSRS. RANSOMES AND RAPIER, LIMITED, IPSWICH.

(*For Description, see opposite Page.*)

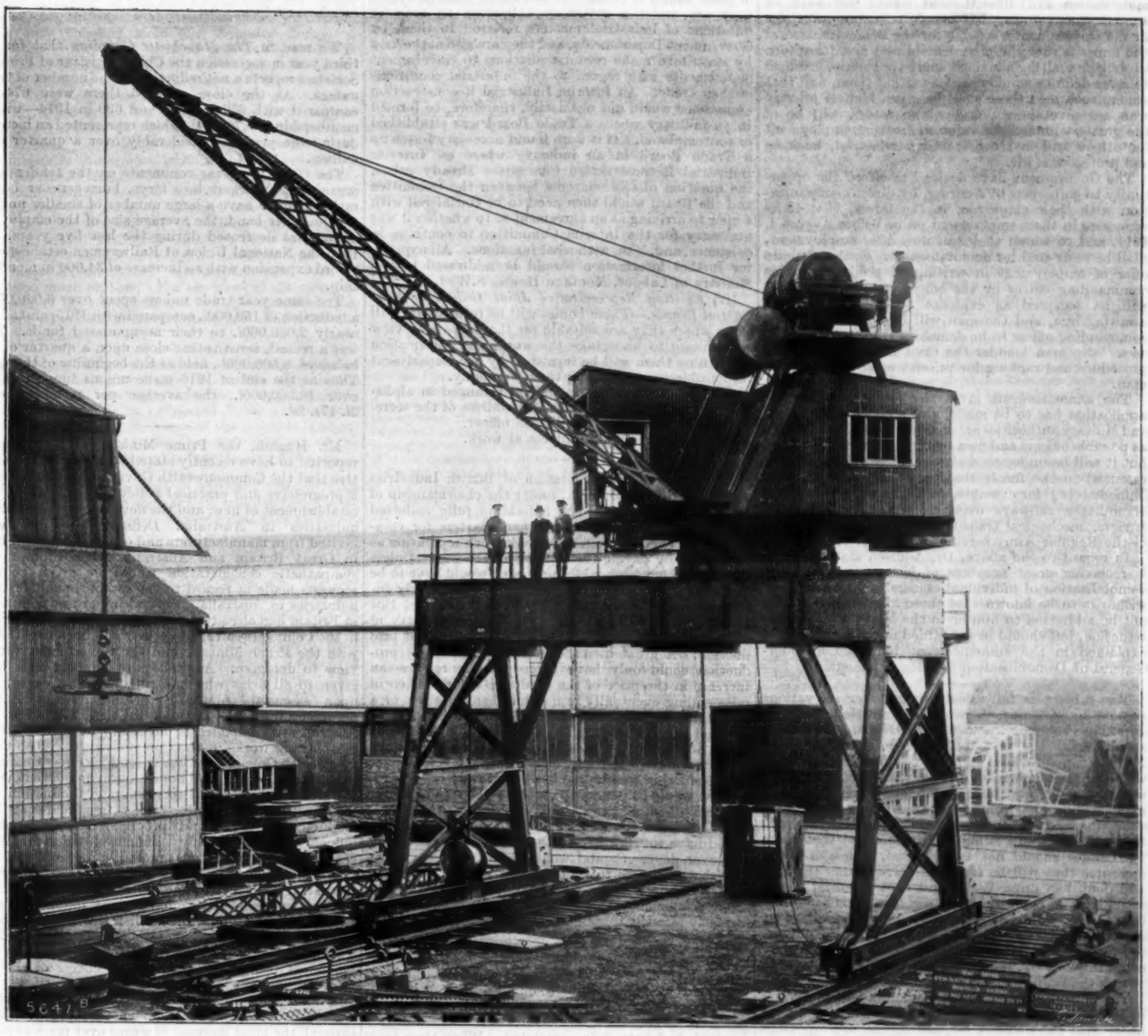


FIG. 3

INDUSTRIAL NOTES.

THE Director of the Department of Labour Statistics deals with the labour market in *The Labour Gazette*, and states that in November employment remained good on the whole, and there was a large unsatisfied demand for skilled labour. The signing of the armistice resulted in a slackening in the engineering trades, though employment was still good; in other metal trades, in the shipbuilding trades, and in the building trades there was a reduction in the amount of overtime worked. There was also a slight decline in employment in the textile industry, but the woollen and worsted and hosiery trades remained busy. A shortage of materials, most generally of fuel, was reported in several industries, but in most cases it would not appear to have resulted in any appreciable degree of unemployment.

Trade unions, with a net membership of 1,140,761, excluding those serving with the forces, reported 0·5 per cent. of their members as unemployed at the end of November, as compared with 0·4 per cent. at the end of October, and 1·1 per cent. a year ago.

Of the 3,686,556 male and female workpeople insured under the National Insurance Acts of 1911 and 1916, the number unemployed at November 22 was 33,634 (or 0·91 per cent.), compared with 0·66 per cent. in the previous month, and 0·82 per cent. a year ago. For males and females separately the percentages unemployed at the end of November were 0·40 and 2·11.

The average weekly number of vacancies notified to all Employment Exchanges for the four weeks ended November 8, 1918, was 38,200, as compared with 40,266 in the previous five weeks and with 43,284 in the four weeks ended November 9, 1917. The average number of vacancies filled for the same period was 28,418, 30,697 and 32,166 respectively. The number of workpeople remaining on the live register at November 8, 1918, was 24,231 men, 36,999 women, 6,376 boys, and 5,906 girls—a total of 73,512.

The principal changes in rates of wages (including war bonuses) reported to the department as having occurred during November were increases of 3*s.* per week for men and women, and 1*s.* 6*d.* per week for boys and girls, engaged in the railway service in the manipulation of traffic; and increases to woollen and worsted spinners and weavers in Yorkshire, raising the total war advance, in the case of time workers, to 104½ per cent., and, in the case of most of the piece workers, to 83¼ per cent. for men and boys and 89 per cent. for women and girls. Other important changes affected workpeople in the textile, bleaching, dyeing, finishing, &c., trades, flax workers in Ireland, workpeople in the employment of tram and omnibus undertakings in Great Britain, and those employed in the manufacture of brick, tiles, pipes, &c.

The Royal Air Force is now open to receive a limited number of boys of good physique with experience of metal and woodworking trades, between 16 and 17 years of age, for training as air mechanics.

Enlistment will be for eight years' service, and four years with the Reserve.

Application for full particulars should be made to the nearest Royal Air Force Reception Depot or to the Local Labour Exchange.

The following is a list of the Royal Air Force Reception Depots: 40, Upper Brook-street, Mayfair, London, W. 1; 8, Tyndall's Park-road, Bristol; 12, Newport-road, Cardiff; Carlton Chambers, 35, Paradise-street,

Birmingham; 8, George-street, Nottingham; 12, Abercromby-square, Liverpool; The Mount, Springfield Mount, Leeds; 10, Sydenham-terrace, Northroad, Newcastle-on-Tyne; 9, Somerset-place, Sauchiehall-street, Glasgow.

The Controller-General of the Department of Demobilisation and Resettlement issued last week an announcement stating that one of the guiding principles in the Government's scheme for the demobilisation of the forces is that the men demobilised first for return to civil life shall include those who have been ascertained to have definite employment awaiting them, and that among such men those shall be given highest priority who are pivotal men and whose return will be of the greatest immediate value in creating employment for others and in reconstructing industrial, business and professional life.

The Government have decided to afford the opportunity to employers of securing, by direct communication with their employees in the forces, that those who were in their employment on or before August 4, 1914, and to whom they can now offer employment, shall be registered for demobilisation. Such a definite offer of employment in writing, if produced to his commanding officer by the officer or man concerned, will be accepted as evidence that employment is awaiting him, and the man will be registered by his commanding officer to be demobilised in the same way as a "slip man" under the Civil Employment Form procedure and ranking for priority after a "pivotal" man.

The announcement gives the form in which the application has to be made, and adds that the Naval and Military authorities are anxious to release as quickly as possible officers and men required for reconstruction, but it will be understood that some individuals are so essential to the forces that they cannot be released immediately; for example, such men as the personnel of military railways overseas, hospital attendants, farriers, mechanical transport, and officers and men in the Regular Army serving on pre-war attestations.

In regard to the above, Dr. Addison states that he is receiving great numbers of letters regarding the demobilisation of individual officers and men, and he wishes it to be known that these applications should not be addressed to him or to the Ministry of Reconstruction, but should be forwarded in the manner fully explained in the announcement by the Controller-General of Demobilisation and Resettlement.

The subject is fully dealt with under its various aspects by a series of pamphlets entitled "Reconstruction Problems" issued by the Ministry of Reconstruction, at the price of 2*d.* each. The pamphlet No. 8, a copy of which we have recently received, deals with the resettlement of civil war workers. It points out that civil resettlement will be divided into two main stages—that prior to the beginning of military demobilisation, and the period when general demobilisation will be in full swing. It is essential that these two stages should not be confused, although many measures that will be found effective during the first will doubtless prove useful and even essential in the second. The main object in the first period must be to tide over a difficult time and to press forward, as far as possible, the passage from war to peace production; the main object in the second, to complete the speedy establishment of industry on a peace basis, and to absorb the returning soldiers, sailors and airmen.

The pamphlet which we recommend to all employers of labour, together with the others of the series, then deals with the demand for labour, the new openings for labour, the Resettlement Department, the measures of resettlement, and those for extending existing employment.

A leaflet entitled "Industrial Reconstruction" is published by the Special Intelligence Branch of the Ministry of Reconstruction, 2, Queen Anne's Gate Buildings, S.W. 1. It gives the list of industries in which representative organisations have been formed to advise and assist the Government on questions concerning their industry, and to undertake such other responsibilities towards the trades they represent as they may themselves determine. Four main types of organisation are represented in the list, as follows:—

(i) *Joint Industrial Councils* (J.I.C.) and Provisional Committees which have been formed to draft constitutions for Joint Industrial Councils (P.D.C. (J.I.C.)) The Ministry of Labour is the department responsible for carrying into effect the proposals of the Whitley Report which have been approved by the Government, and all requests for further information should be addressed to the Ministry of Labour, Montagu House, Whitehall, S.W. 1.

(ii) *Interim Industrial Reconstruction Committees.*—These Committees have been formed by the Ministry of Reconstruction in association with the Board of Trade and Ministry of Labour in certain industries where, owing to various reasons, progress towards the formation of Joint Industrial Councils has been slow. All requests for further information should be addressed to the Trade Organisation Section, Ministry of Reconstruction, 2, Queen Anne's Gate Buildings, Westminster, S.W. 1.

(iii) *Trade Boards.*—Apart from the primary function of these bodies of fixing legal minimum rates of wages, they are under a statutory obligation to consider questions of industrial matters referred to them by Government Departments, and they are also authorised by statute to make recommendations to Government departments with regard to the industrial conditions in their trade. An Interim Industrial Reconstruction Committee would not ordinarily, therefore, be formed in an industry where a Trade Board was established or contemplated. If it were found necessary to set up a Trade Board in an industry where an Interim Industrial Reconstruction Committee already exists, the question of the relations between the committee and the Board would then need to be considered with a view to arriving at an agreement as to whether it was necessary for the Interim Committee to continue in existence, and, if so, with what functions. All requests for further information should be addressed to the Ministry of Labour, Montagu House, S.W. 1.

(iv) *Existing Representative Joint Bodies, such as Control Boards.*—These bodies will be recognised in all cases where they are suitable for the purpose in view and willing to undertake the work, and information concerning them will be furnished by the Department responsible for appointing them originally.

The leaflet gives the industries arranged in alphabetical order, with the name and address of the secretary, and the name of the liaison officer.

There are now 29 committees at work.

A meeting of the Federation of British Industries was held on the 12th inst., under the chairmanship of Sir Vincent Caillard. The federation fully endorsed the arguments advanced in other quarters for compelling the enemy countries to make such reparation as is possible by paying the full cost of the war. Unless the enemy countries paid, the burden would have to be borne by this country in the form of immensely increased taxation for many years to come, and this taxation would fall ultimately upon the industry of the country and form an element in the cost of production. A great increase in the total cost of production could only have three possible results—an increase in the price of the product; a diminution in sales ending eventually in national bankruptcy; or a reduction in the remuneration received by all classes engaged in production. The first would be impossible owing to the competition of the countries who have taken no part in the war, or who have taken a lesser part than this country, and whose total cost of production would consequently be less; the second meant national disaster; the third would mean that producers of all classes—employers and employed alike—would have to work harder and receive less than they had ever done. Capital would be driven away from British enterprises to those of less heavily burdened countries, and both the creation of new industries and the development of those already in existence would be seriously restricted.

The twenty-eighth ordinary general meeting of the shareholders of Messrs. Dorman, Long and Co., Limited, was held in Middlesbrough on the 16th inst. Sir Arthur J. Dorman, K.B.E., who presided, said that the purchase of the shares of Sir B. Samuelson and Co., Limited, had been duly completed. When they took over the assets of the latter company, they acquired an interest in the Itabira Iron Ore Company, Limited, and the directors were represented on the Board. The iron ore properties owned by the Itabira Company were situated in Brazil, and in view of the large reserves of exceptionally high-grade ore they contained, they were of considerable interest to the steel trade. The directors were of opinion that eventually this ore must have an important influence upon the iron trade of the world, and they felt they ought to watch its development. Dorman Long held also a large interest in the Channel Steel Company, which controlled the iron ore area of Dover and other potential areas in the same field. They were, further, interested in the development of another coal area of some 5,000 acres in Kent. The interest which was being evinced in the Kent coalfield in a practical form by some of the most important metallurgical firms in France confirmed his view that this field was likely to have an important future. The company had also important coal properties in Durham. Their Redcar works now formed one of the most important parts of their undertakings.

The directors of the Tinsley Park Colliery Company, Limited, have issued the report and accounts for the year to September 30 last, and recommend the payment of a final dividend of 7½ per cent. net, making 12½ per cent. for the year.

The report states that an agreement has been made for the Sheffield Gas Company to take the surplus gas from the company's coke ovens and, on the 9th inst., this gas was turned into the main for conveyance from the coke ovens to the Grimesthorpe works of the gas company. The quality so far is said to be quite satisfactory.

We read in *The Manchester Guardian* that for the third year in succession the Chief Registrar of Friendly Societies reports a net reduction in the number of trade unions. At the close of 1916 there were 674—as compared with 677 in 1915 and 690 in 1914—with a membership of 3,703,001, which represented an increase during the year of considerably over a quarter of a million.

The Chief Registrar comments on the tendency to organise the workers into large, homogeneous bodies rather than to have a large number of smaller unions. On the other hand, the average size of the employers' unions has decreased during the last five years. In 1916 the National Union of Railwaymen established a record expansion with an increase of 34,000 in membership.

The same year trade unions spent over 3,040,000*l.*, a reduction of 150,000*l.* compared with 1915, and added nearly 2,000,000*l.* to their accumulated funds. This was a record, constituting close upon a quarter of the balances, 8,500,000*l.*, held at the beginning of the year. Thus at the end of 1916 trade unions funds totalled over 10,500,000*l.*, the average per member being 2*l.* 17*s.* 2*d.*

Mr. Hughes, the Prime Minister of Australia, is reported to have recently stated to a press representative that the Commonwealth Government had adopted a progressive and practical policy for encouraging the establishment of new, and the development of existing, industries in Australia. Definite proposals were invited from manufacturers and others interested, both in Great Britain and Australia, when prompt and sympathetic consideration would be given to any requests made in regard to the establishment of their industries in Australia. Several important companies in Britain had already decided to commence operations in the Commonwealth, and others had been negotiating with the Prime Minister and the Government with a view to doing so. Assurances of support had been given to all firms who had satisfied the Government upon essential points. Representatives of British manufacturers had in some cases already left for Australia to complete the necessary arrangements for establishing works in the Commonwealth. The Commonwealth Government was sparing no effort to attract capital to Australia, and hoped, by so doing, to develop its great resources and to encourage production and trade within the Empire, both of raw materials and manufactures on sound progressive lines. Enemy influences were entirely eliminated from Australia early in the war, and the present programme of the Commonwealth Government followed the policy of reconstruction which he had repeatedly advocated here.

The Commonwealth offered great inducements to British manufacturers to establish works in Australia, where abundance of raw materials of almost every kind was available, and where the industrial situation was much less disorganised through the effects of the war than in Britain and many other countries. The post-war cost of production in Britain would, he further stated, be much higher than that of pre-war days, through the great increase of wages over pre-war rates, and the higher price of raw materials owing to the high freight rates and other causes. In Australia, on the other hand, manufacturers would have raw materials at their doors and efficient labour at wages fixed by legal tribunals. Post-war conditions in Australia would be much less disturbed through the effects of the war than would be the case in Britain. Pre-war wages in Australia were, of course, much higher than in Britain before the war, but owing to obvious causes this disparity was not now likely to be so marked in the future, and therefore the advantage to manufacturers of producing the goods in a country where the raw materials were at hand was such as to offer considerable inducements to manufacturers to establish works in Australia.

The Minister of Munitions has given notice that all incompleted contracts for the Admiralty, War Office and Ministry of Munitions which have been placed in classes A or B, including the various grades thereof P 1 to P 6, under the Order as to priority of March 8, 1917, need no longer be given the priority attaching to them under the Order, except in cases where the contractor is notified in writing or by official notice in the Press that a particular classification is still required to be given to any particular contract. Contractors

must notify the ordering departments of the Admiralty, War Office or Ministry of Munitions responsible for the contracts in question, of any modification of the original date of completion resulting from this relaxation of the Order as to priority.

As umpire for the National War Labour Board, Mr. Henry Ford, says *The Iron Age*, New York, has decided in favour of the basic eight-hour day in the case of the International Association of Machinists *versus* the Wheeling Mold and Foundry Company, Wheeling, W.Va. The decision provides also for the payment of time and one-half for overtime, and double time on Sundays and legal holidays. "But I cannot refrain from expressing my very deep conviction," adds Mr. Ford in his letter to the Board, "that the straight eight-hour day is much better practice than the so-called 'eight-hour basic day,' where the latter is continually and almost uniformly being practically exceeded in the number of working hours. My experience, and also my reason, teaches me that very few emergencies ever exist in a manufacturing business, justifying the practice of exceeding eight working hours per day. The strain of eight hours is enough, and the hours should never be increased except under the most extraordinary circumstances. I cannot dwell too much on this. For the good of the men, for the good of the employer, and for the general results, I would admonish those interested to adhere to the straight eight-hour day."

It is stated that coal miners are returning from the army in a constant stream. Up to the present the number of men who have returned is approximately 75,000, of whom it is estimated 7,500 are Scottish miners. The rate of discharge at the moment is about 5,000 per day, so that there is every prospect of the first 100,000 being released before the end of the year.

Progressive improvement in shipyard rivet-driving, despite a continuing shortage of trained men, is an index of efficiency in yard management, says *Engineering News Record*, New York. In the development stage of the yards, shipbuilding could not be organised in such a way as to yield a high output per man. This was as true of shops, transportation and erection work as of riveting, but the detailed recording of performance for the latter made it the outstanding element of the shipbuilding situation. Improvement of the production system in the yards correspondingly finds expression in higher riveting figures. Piece-work payment is one of the instruments of efficiency. Yard tests have proved conclusively that time payment gives inferior rivet outputs: yet during the period when the yards were not fully organised for the extra burden of work placed upon them, when speed had to be secured at the cost of efficiency, piece-work riveting was not everywhere practicable—in some instances it was impossible even to supply work regularly enough to enable the gangs to make fair earnings on piece work. Since then, extension of piece work and rise in rivet output have gone hand in hand. The shipyards are working under full pressure, and specialist training is helping to solve the remaining difficulty of labour supply.

Speaking at the annual meeting of the Millom and Askam Iron Company, which was held in Preston last Tuesday, Mr. G. Mure Ritchie stated that the capitalisation of the company had been altogether outgrown by the development of the company's business and by expanding prospects, and they hoped for additional profits from various sources in the future, unless they should come under the reign of Socialism and Bolshevism. The time had arrived when the capital of the company should be rearranged.

If they could suppose that normal conditions would be resumed it would be reasonable to infer bright prospects for the company, but there were difficulties and dangers to be faced. Some of these rested with the Government of the future and some with the workers of the country. He deplored, notwithstanding increased wages, that there had been a falling-off in the production in various directions, although he paid a compliment to the workers at Millom for their loyalty, pointing out that there had been no strike there for a quarter of a century.

Many British industries showed prosperous conditions at present owing to Government subsidies, but these could not go on indefinitely. The British taxpayer, sooner or later, would realise that he had got to foot that Bill, and would object to it. Wages would never go down to the old level, and he thought it would be a good thing if workers could become capitalists, in a small way at the beginning, with increasing prospects, and so they would have a greater stake in the country.

He welcomed the Premier's announcement regarding protection for "key" industries, and, with the fiscal policy of the country reframed and preference extended to overseas Dominions, they could look forward to the development of the iron and steel industry.

THE OPTICAL SOCIETY.

A MEETING of the Optical Society was held on December 12 at the Imperial College of Science and Technology, Professor F. T. Cheshire, C.B.E., president, in the chair. A paper was read by Instructor-Commander T. Y. Baker, R.N., and Major L. N. G. Filon, F.R.S., R.A.F., on "*An Empirical Formula for the Longitudinal Aberration of a Ray through a Thick Lens.*" The authors showed that the development of the longitudinal aberration as a power series is frequently illegitimate owing to its divergency for comparatively slight inclinations of the rays. Instead of such development of the form $a t^2 + b t^4 + \ldots$ where t is the tangent of the inclination of the ray they proposed a formula $A t^2/(1 + B t^2)$ and determined A and B numerically from the values of the aberration of particular rays calculated trigonometrically through a lens. This was done for a whole series of image positions and for a whole series of lenses of different shapes, but of the same focal length. The numerical values of A and B so obtained were then analysed and an endeavour made to obtain approximate general formulæ for them in terms of the image position and the lens shape. The authors decided that in all cases the value A in their empirical formula and the value a in the power series were practically identical. The value of a was given by the authors in a paper before the Society in May. The value of B can be expressed as a cubic in M, the linear magnification of the image. Thus $B = B_0 + B_1 M + B_2 M^2 + B_3 M^3$, in which the four coefficients B_0 B_1 B_2 B_3 are all quadratic functions of the mean curvature of the lens faces. The general form of the formula being thus established steps were taken to test it over a series of image positions and a series of lens shapes. It was found that out of 30 tests the formula was in error in two cases by amounts equal to 1·3 per cent. and 1·7 per cent. of the aberration. In the other cases the error of the formula was of the order of 0·1 per cent. of the aberration. The authors expressed the opinion that as the longitudinal aberration could be expressed in general form by the use of two parameters, it might be of considerable service to calculating opticians if these constants could be tabulated.

In the discussion which followed Messrs. T. Smith, S. D. Chalmers, M.A., and R. S. Clay took part.

A paper was then read by Major E. O. Henrici, R.E., on "*Spirit Levels*," and discussed by Messrs. E. H. Rayner, S. D. Chalmers and R. S. Clay.

Major E. O. Henrici, R.E., drew attention to the fact that the best bubble tubes for spirit levels have been made in Germany, and that it seemed desirable that an investigation should be made of the factors necessary for producing satisfactory tubes. He pointed out the advantage of a long air bubble both as regards the accuracy and rapidity with which the bubble comes to rest when displaced, and the advantage of a short radius of curvature as regards the latter point. The radius of curvature (in other words the sensitiveness) must, however, be sufficiently great for the bubble to move noticeably with the smallest angular tilt of the tube which it is desired to indicate. If the bubble be too sensitive time is lost, if it be not sufficiently sensitive a spurious idea of accuracy is given; the sensitiveness of every bubble tube for accurate work should be marked.

The methods of mounting, illuminating and viewing the bubble tube frequently leave much to be desired, and improvements in these matters lead to increased accuracy for a given sensitiveness. Several methods of viewing by means of prisms were described, the most satisfactory known to the author being one placed on the market by Zeiss.

The accuracy of shaping the surface required in a sensitive bubble is very great. If a tube has a corrugated surface, the corrugations having an amplitude of 1/200 mm., and a period of 10 mm., the angle of tilt to move the bubble 1 mm. may vary 38 per cent. from its nominal value in the case of a bubble with a sensitiveness of 10 seconds per millimetre, the bubble being 35 mm. long. A similar corrugation with a 2-second bubble will make it almost useless for any purpose.

Further investigation is required into the effect on the performance of the bubble of the following factors: Quality, polish, and cleanliness of the glass, quality and purity of the liquid and vapour in the tube, and the best methods of mounting and viewing.

THE ELECTRICAL POWER SUPPLY COMMITTEE.—The Board of Trade have appointed Sir John Snell to act as their adviser on all matters arising out of the report of the committee in question.

PRICES OF PETROLEUM PRODUCTS.—We are informed by H.M. Petroleum Executive that His Majesty's Government have made the following reductions in the price of petroleum products: From December 16 gas oil will be reduced 7½*d.* per gallon, fuel oil 4*l.* per ton. From January 1 petrol will be reduced 3½*d.* per gallon, kerosene 4*d.* per gallon. It is understood that these reductions are consequent on the improved shipping position resulting from the armistice. A Board of Trade Order will shortly be issued to this effect.

BOILERS REVOCATION ORDER.—The Minister of Munitions has issued an Order dated December 13, revoking the Boilers Returns and the Boilers Control Orders, which provided respectively (*a*) for the making of certain returns and (*b*) that no person except with a permit might purchase, sell or deal in any second-hand steam pressure boiler other than boilers for use in locomotives, motor cars, vehicles or ships. The Order did not, however, authorise dealing in boilers for which a permit is required under the Railway Material (Second-hand) Order, 1916.

THE PRESENT STATE OF THE GERMAN MERCHANT FLEET.

BEFORE the war the German merchant fleet amounted to 5,134,720 tons; of this total some 2,500,000 tons have been taken, one way or another, by hostile countries. Further losses and dilapidations have occurred during the war, and now not more than 2,000,000 tons can be reckoned upon as being available in German ports. It has been rumoured and even stated with some authority, that energetic and extensive building to make up for this has been going on at the German shipyards, but this can hardly be correct. Since 1916 the naval and military authorities have monopolised the yards, and since the autumn of that year, with a few isolated exceptions, all building of mercantile tonnage has been entirely prohibited. The vessels which were taken in hand or contracted for in 1914 are consequently not ready yet. In April, 1917, the Hamburg-America Company, for instance, had contracted for 16 large boats of an aggregate tonnage of 323,000 tons, and the North German Lloyds had a similar number of vessels ordered with an aggregate tonnage of 216,000 tons, 25 additional vessels with a tonnage of 325,000 tons being ordered by four other shipping companies. According to what Herr Ballin stated shortly before his death none of the above vessels had then been completed. The few boats for which the necessary permits had been obtained were only some iron ore boats for the Baltic trade and a number of trawlers of service to the naval authorities.

The annual output of the German yards before the war amounted to some 300,000 tons. All the old yards have materially increased their plant and capacity during the war and a fair number of new yards have sprung up, so provided an adequate supply of raw materials can be secured, the capacity may have been about doubled. The loss of Alsace-Lorraine and of the occupied districts, however, will to a substantial extent reduce Germany's former supply of ore.

The Act of last year providing extensive State aid to the rebuilding of the German merchant navy caused the works to be simply flooded with orders.

The financial position of the German shipping concerns has steadily deteriorated during the war; no reports have been forthcoming as far as most of the leading companies are concerned, and with a few exceptions the shareholders have received no dividends. Several amalgamations of shipping undertakings have been completed, and some concerns have been bought up by leading industrial companies. In this direction Herr Hugo Stinnes has been particularly active and has now became one of the leading men in German shipping. He is understood to have contracted for over 250,000 tons of new tonnage during the war.

The *Vorwaerts*, some little time ago, dealt with the future of German shipping and took a very pessimistic view. The expenses of shipping after the war would, thought the paper in question, be so heavy that the State subvention would not by a long way suffice to meet them. On the other hand the shipbuilding industry was likely to be very prosperous for the first five to six years. The number of older German yards is put at 22, of new at 20, with an aggregate of 50 new slips. Germany more than any other country will be in need of tonnage; imports sufficient to cover the country's most important requirements are estimated to represent a value of from 12,000,000,000 marks to 15,000,000,000 marks, for the carriage of which a vast amount of tonnage is needed. Regulations have been drawn up so as to ensure a gradual import of the different commodities according to their importance.

ELECTRIC LIGHT AND POWER AT PENANG.—According to *The London and China Telegraph*, the recent annual report of the electricity supply and electrical tramway departments of the municipality of Penang indicates what in normal times would prove valuable openings for British trade. The electricity supply department was in a state of arrested development during 1917, its thirteenth completed year, so far as extensions of a capital nature were concerned; and maintenance was carried on with increasing difficulty, owing to war conditions. As regards private supply there was a net increase of 302 installations. The number of fans of all types totalled 1,608, of which 167 were added during the year. The manager is of opinion that in view of the great comfort and advantage to health to be obtained by a liberal use of fans the number of such connections is small, and that the introduction of a reliable cheap ceiling fan of small size, for the benefit of the smaller consumers, would probably prove as profitable to contractors as it would to the department. Owing to the enhanced prices of maintenance materials, the expenditure figures show an increase of 25·3 per cent. The total capital outlay at the end of the year amounted to more than $600,000 gold, of which about $8,500 was incurred during the year, mainly on distribution cables and meters. The balance of revenue over expenditure represented a gross profit of 20·3 per cent., or a net profit of 10·3 per cent., which in a year of enforced comparative inactivity might be considered a very satisfactory result. The twelfth year of operation of the tramways was somewhat uneventful. The number of passengers carried showed a satisfactory increase, but enhanced prices had to be paid by the department for all materials purchased; and no work of a capital nature was possible, owing to the impossibility of obtaining materials. An electric locomotive to deal with freight haulage was ordered from America. The figures for revenue are a record, being $87,275 gold, and the financial result showed a gross profit of 10 per cent., a result that bears favourable comparison with the returns of similar home undertakings.

NOTES ON LAUNCHING.*

By Mr. William Gatewood, Member.

In connection with the launching of large and heavy vessels, for which launching calculations are made, two conditions of the operation usually receive especial attention :—

The pivoting pressure, or reaction on the ways when the stern begins to lift.

The minimum moment against tipping.

The calculations as usually made are well known to naval architects, and may be found described in the transactions of this and kindred societies, and in text-books on naval architecture. The calculations assume that the level of the surface of the water is not disturbed by the entrance of the vessel, that the vessel itself remains rigid, and that the alignment of the groundways is not disturbed by the passage of the vessel. The pressures and moments obtained by the calculations must necessarily be approximations only, since the assumed conditions cannot exist in the actual launching. It is probable, however, that the results are relatively comparable, and that the calculations can be relied on with confidence in making the essential preparations for the launching.

Pivoting Pressure.—Suitable provision for taking the pivoting pressure on the fore poppets was early recognised as essential, because the concentration of pressure received visual confirmation at almost every launching. It was recognised, also, that some means of distributing this pressure is necessary, as theoretically the pressure is concentrated on the extreme forward end of the sliding way. In the early days, the fore poppets were built of timbers on end, but it was soon noticed that this was not a good practice, as the compression of end-grain wood is quite small compared with the compression when the grain is flat. By building up the forepoppets with the wood laid flat, an appreciable amount of compression occurs at the forward end when the vessel pivots, and the under surface of the sliding way is enabled to remain in contact with the upper surface of the groundway over an appreciable length, thus distributing the pressure between the two pairs of surfaces.

As the launching weight of vessels increased and the pivoting pressures changed from a few hundred tons to more than 2,000 tons, some more definite means of distributing this pressure became necessary. The introduction in the fore poppets of a considerable depth of soft wood with grain flat seems to have served the purpose in some cases, notably in the launching of the Lusitania and Mauretania. A special rotating device or rocker formed as a segment of a trunnion has been used successfully, as described in vol. xxii of the transactions of this Society. Curving or cambering the forward end of the fore poppet cribbing to introduce a clearance for the adjustment of the bearing surfaces has been used, as noted in the discussion on the paper above referred to. Strips of soft wood especially proportioned to crush under pressure were used in the fore poppets of certain vessels on the Pacific Coast, as described in vol. xii of the Transactions of this Society.

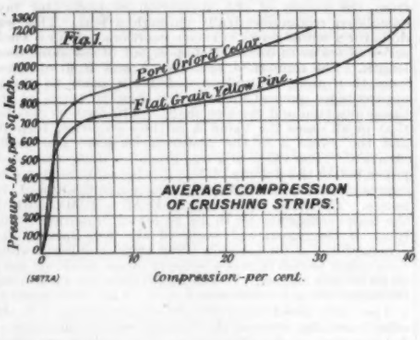
The use of crushing strips in the fore poppets seems the most simple and the most effective method of distributing the pivoting pressure, and the calculations to determine the number, size and spacing of the crushing strips are not very elaborate. It is desirable, of course, to select for the crushing strips material which is uniform in quality; and white pine, flat grain yellow pine, or Port Orford cedar would seem suitable, as fairly uniform material can be obtained and the compression curves show the proper characteristics. In Fig. 1 are shown average compression curves for flat grain yellow pine and Port Orford cedar. These curves indicate that crushing begins at about 650 lb. per square inch for yellow pine and at about 750 lb. for Port Orford cedar, for which pressures the compression is less than 4 per cent., and that for a compression or crushing of 30 per cent. the pressure are about 950 lb. per square inch and 1,200 lb. per square inch respectively. These curves are based on samples of width equal to or greater than their height, and the variation of pressure from the mean at 30 per cent. compression was less than 10 per cent. for a large number of samples, when care was taken to eliminate resiny and unseasoned yellow pine. Slightly different values were obtained when the width was less than the height.

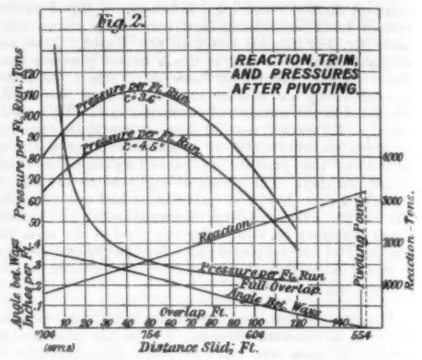
In order to determine the most suitable arrangement of crushing strips, it is necessary to calculate the reactions and the change in grade of the keel or sliding ways for several positions after pivoting. In Fig. 2 the reactions for a certain vessel are plotted in tons, and the angle between the sliding way and the groundway in inches per foot of length on base of distance slid and of length of overlap of ways. The curve of minimum mean pressure per foot run is obtained by dividing the reaction by the length of overlap of the ways, and it is evident that such pressure can only be obtained if the whole of the overlap of the ways is in bearing. They are based on static launch, and are modified materially when the overlap is approaching zero by the launching velocity of the vessel as compared with the pitching period of the vessel.

The height and general construction of the fore poppet will determine what depth of crushing strips can be fitted, and the maximum crushing in inches which can be counted on will regulate the portion of the overlap of the ways which will be in contact. If we call the reaction R, and the angle between the ways expressed in inches per foot of length as a, and the maximum crushing at the forward end of the fore poppet as C then the length of overlap in bearing will be $C \div a$; and the mean pressure per foot run on this bearing will be $\frac{R \cdot a}{C}$. The value of this mean pressure is plotted in Fig. 2 for two values of C — 3·6 in. and 4·5 in., corresponding to 30 per cent. compression on 12 in. and 15 in. depth of crushing strips respectively. A convenient method of determining the distribution of the crushing strips would be to take the maximum pressure as thus determined and lay it off at the after end of the overlap in bearing corresponding to the position of the vessel where this maximum occurs (17·3 ft. aft of forward end of fore poppet for C = 4·5 in. from data on Fig. 2), and consider it as the pressure at which crushing should just start. At the forward end of the fore poppets lay off a pressure at which crushing should just start if, when the crushing corresponds to the value of C, the pressure is the same as the pressure laid off at the after end of the length in contact. This will be about 70 per cent. of the mean pressure if flat grain yellow pine is used and 30 per cent. compression is allowed in determining the value of C. When these two spots are joined by a straight line, we have the distribution of pressure at which crushing should just start to give a uniform pressure over the length of bearing when account is taken of the crushing.

It will be found that the pressures at which crushing should start for points aft of this region may be laid off to advantage the same as the highest point just determined, and for a distance aft such that the area of the pressure diagram is equal to the pivoting pressure. The diagram will show the distribution of pressures at pivoting, as a greater pressure at any point would crush the strips, and this cannot occur before there has been a change of angle due to pivoting.

The curve of maximum pressure per foot run can be obtained by laying out the distribution of pressure for intermediate positions of the vessel up to the jump off the ways, although, as previously mentioned, the excessive pressures on the tip of the fore poppets would be experienced under static conditions only. Such a curve is indicated in Fig. 3. This curve shows a certain amount of crushing at points where later there is no crushing or less crushing, and the elasticity of the wood will probably enable the crushing strips partially to accommodate themselves to this condition, provided the percentage of crushing is not too great.





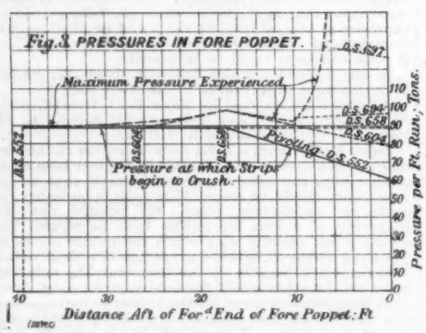


Fig.3. PRESSURES IN FORE POPPET.
Maximum Pressure Experienced.
Pressure at which Strips begin to Crush.
Pivoting
Pressure per Ft. Run; Tons.
Distance Aft of Fore End of Fore Poppet; Ft.

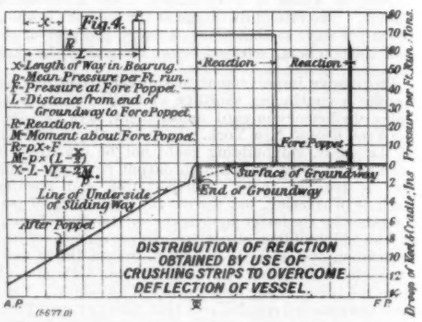


Fig.4.
Reaction
Fore Poppet
Surface of Groundway
End of Groundway
Line of Underside of Sliding Way
After Poppet
DISTRIBUTION OF REACTION OBTAINED BY USE OF CRUSHING STRIPS TO OVERCOME DEFLECTION OF VESSEL.
Drops or Rises (Cradle) Ins. Pressure per Ft. Run. Tons.

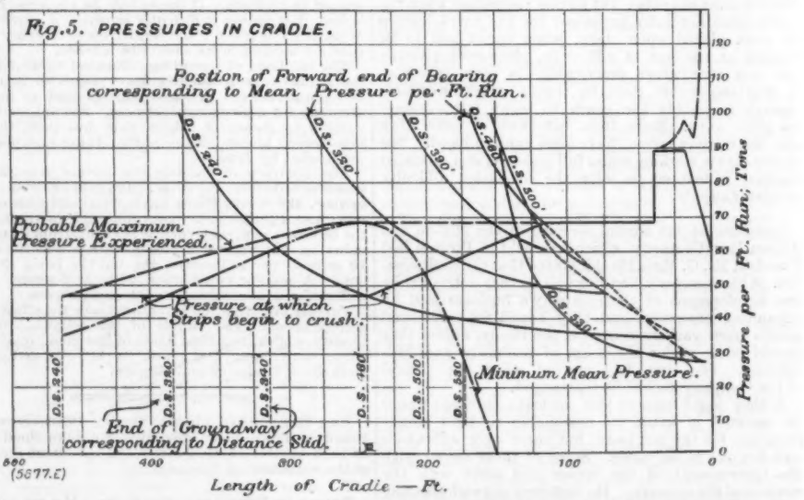


Fig.5. PRESSURES IN CRADLE.
Postion of Forward end of Bearing corresponding to Mean Pressure pe. Ft. Run.
Probable Maximum Pressure Experienced.
Pressure at which Strips begin to crush.
Minimum Mean Pressure.
End of Groundway corresponding to Distance Slid.
Pressure per Ft. Run; Tons
Length of Cradle — Ft.

The pressures obtained by this method would probably be reduced somewhat by the bodily lowering of the vessel due to the crushing, unless the pivoting point assumed in the calculations corresponds to the point of no crushing.

Fig. 7 is from a photograph of the fore poppets of a vessel with crushing strips arranged somewhat as described in the preceding example. The crushing strips seemed to serve their purpose admirably, distributing the reaction over the strap supports and distributing the pressures over the standing ways so that no trouble at all was experienced from the high pivoting pressures. The same arrangement was repeated for a sister vessel with similar success, the material of the crushing strips being white pine, which has about the same crushing curve as yellow pine. It will be noticed that the crushing strips are in four layers, which gives stability to the structure; and there is a further crushing of the division boards where the crushing strips bear, which adds to the adaptability of the design to distribute the pressures.

Further refinements may be made in the calculations if desired, to obtain full advantage of this method of

* Paper read before the Society of Naval Architects and Marine Engineers at Philadelphia on November 14, 1918.

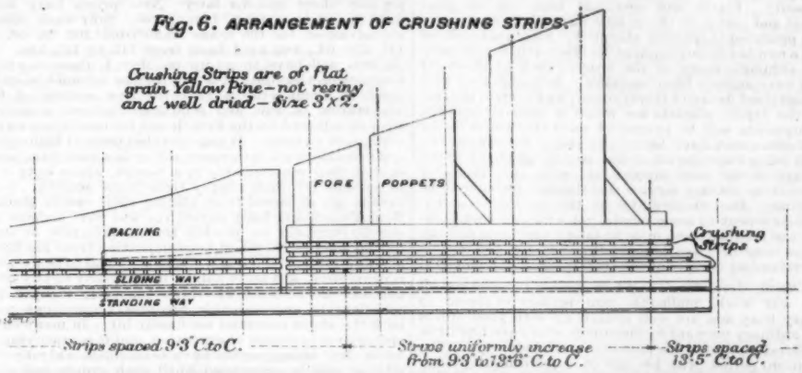
distributing the pressures. On the other hand, the crushing strips are able to stand almost any amount of overloading without disintegrating, and their use cannot fail to help distribute the pressures, even if fitted without reference to any calculations at all.

Way End Pressure.—The minimum moment against tipping is primarily the measure of safety against the lifting of the fore poppets from the ways and the bodily tipping of the vessel backwards as the centre of gravity of the vessel passes the end of the groundways. Many of the smaller vessels have "tipped" in launching because it was considered too expensive to extend the ways a suitable distance under water. Usually, no damage has resulted from this practice, as the pressures have been comparatively small, and the ways were so supported as to "give" appreciably during the tipping.

On larger vessels, however, even with a considerable moment against tipping, damage to the floors under the flat of the bottom has resulted, caused by the concentration of pressure over the outboard end of the ground ways as the part of the vessel which was damaged passed over that spot. This concentration of pressure is not indicated directly by the calculations as usually made. Special calculations are often made, however, in an endeavour to determine these pressures. In these calculations, it is assumed that the vessel and ways do not change shape and that the distribution of reaction on the ways can be represented by the ordinates of a trapezoid, having a length equal to the overlap of the ways, an area equal to the total reaction corresponding to the particular overlap selected, and with the centre of gravity of the trapezoid at the centre of gravity of reaction. If the centre of gravity is nearer the end of the groundways than one-third of the overlap, the trapezoid becomes a triangle whose base is three times the distance of the centre of gravity from the end of the groundways, and there is assumed to be no pressure at all at the forward end of the fore poppets. This method of determining the pressures under the bottom of a vessel was used in preparing for the launch of the Lusitania, was described in vol. xii and was illustrated in vol. xxii of the Transactions of this Society.

The method of determining pressures under the bottom, above described, is based on an assumption which can hardly be realised in practice. The condition which controls would seem to be that the vessel does not remain straight, but yields to the bending forces which come into play during the launching. The natural impression which one gets of a large vessel afloat is that there is no longitudinal bending. Both theory and actual measurements, however, show that vessels are flexible beams, and records of measurements are given in our Transactions. In the process of launching, the bending moments are quite pronounced and can be approximated with some degree of certainty, although considerably more data must be accumulated before they can be calculated with accuracy. Measurements taken during launching show the effect of these bending moments on the upper deck, as the stringers show considerable stretching during the passage of the vessel down the ways.

Fig. 6. ARRANGEMENT OF CRUSHING STRIPS.


Crushing Strips are of flat grain Yellow Pine—not resiny and well dried—Size 3"×2".
FORE POPPETS
PACKING
Crushing Strips
SLIDING WAY
STANDING WAY
Strips spaced 9·3" C to C.
Strips uniformly increase from 9·3" to 13·5" C to C.
Strips spaced 13·5" C to C.

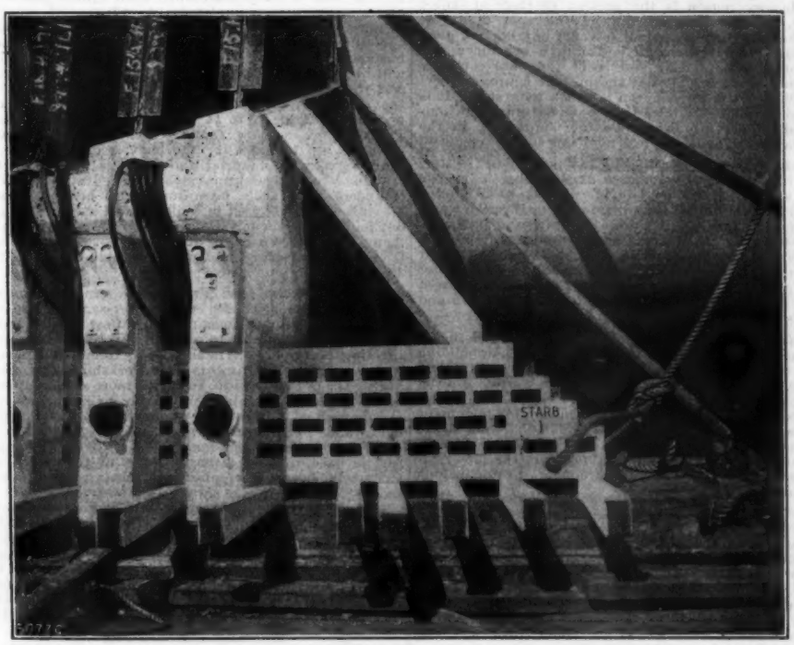


FIG. 7.

The effect of this bending of the vessel is to tend to concentrate the reaction of the ways prior to pivoting at two points—the outboard end of the groundways and the forward end of the fore poppets. The relative intensity of these two forces would vary to suit the centre of reaction, and the sum of the two forces would be the total reaction on the ways, or land-borne weight. The reaction at the outboard end of the groundways would be a maximum before the position of minimum moment against tipping is reached, and is equal to:

$$\frac{W a - B y}{l}$$

in which $W a$ is the moment of the weight about the forward end of the fore poppet; $B y$ is the moment of buoyancy about the forward end of the fore poppet; l is the overlap of the ways.

The settling of the ways, compression of the packing, and deformation of the bottom of the vessel all tend to distribute this way-end pressure, but it is manifestly unlikely, if not impossible, that the distribution of pressure can be as indicated by the trapezoidal formula. The use of crushing strips in the packing under the bottom has suggested itself as a means of distributing this bottom pressure, just as it has served as a satisfactory means of distributing the pivoting pressure. The calculations to determine the amount of the crushing strips required are not so simple as in the case of the fore poppet strips, but the following method would seem applicable.

From the launching calculations, determine for several positions of the vessel the reaction on the ways and the moment of this reaction about a point chosen, say, 10 ft. aft of the forward end of the fore poppets. Determine as indicated in Fig. 4, the length from the after end of the cradle over which a certain mean pressure per foot run must be applied to afford a reaction which will have the same moment as above described. Obtain similar lengths for other mean pressures, and plot the series of curves through the points so obtained (see Fig. 5). Note the points on these curves at which the reaction at the fore poppet becomes zero, as this gives the minimum mean pressure which is practicable. The highest point of the curve joining these points of minimum mean pressure gives the maximum mean pressure which need be experienced if the crushing strips are suitably arranged.

If the strips are arranged so that they will just begin to crush at the forward end of the bearing thus determined; and if they are arranged at the after end of the bearing, over the end of the groundways corresponding to this position of the vessel, so that they will give this pressure per foot run after having crushed sufficient to permit of this length of bearing; the mean pressure per foot run over the whole length of bearing may be obtained by arranging the strips in between so that they will begin crushing at the proper pressure to give this mean pressure after crushing to suit the curvature of the vessel in this position. It is assumed in the diagram on Fig. 5 that a straight line variation will prove satisfactory.

If we assume that the wedging up has adjusted the cradle so that no bending will occur to localise the pressures until after the after end of the cradle has passed the end of the groundways, it will be seen that in the after poppets the pressure will be not much different from the mean pressure due to the weight of the vessel. In that part of the cradle, therefore, the crushing strips can be arranged to give only a slight margin over this mean pressure, say about 25 per cent., to allow for irregularities in the strips.

The crushing strips can be arranged to give uniformly varying pressures between the after end of the cradle and the outboard end of the bearing for maximum mean pressures (shown uniform in the diagram) without causing the above determined maximum mean pressure to be exceeded. Between the inboard end of this bearing and the outboard end of the fore poppet bearing, an arrangement of strips to give uniform beginning of crushing would seem satisfactory.

In order to determine with accuracy the maximum pressures over the way-end when crushing strips are fitted as above outlined, it will be necessary to calculate the deflection of the vessel in several positions and plot the pressures corresponding to the crushing and spacing of the strips, as indicated in Fig. 5, to give the proper reaction and moment. The curve shown in Fig. 5 represents the probable maximum pressures which will be experienced if the crushing strips are sufficiently thick actually to cause the sliding way to accommodate itself to the groundway.

In Fig. 6 is shown in part the distribution of crushing strips which corresponds to the pressures shown on Fig. 5. Four rows of 2-in. by 3-in. strips are shown in the fore poppet, one row is used where the height is limited, and two rows amidships and aft where there is sufficient height to fit them.

One further condition needs to be mentioned. Although the crushing strips do not exert nearly as much pressure in returning to their original thickness as they do in being crushed, the recovery is appreciable, and there will be a considerable pressure exerted between the bottom of the vessel and the sliding way outboard of the end of the groundway. This pressure may be sufficient to break the sliding way if there is an appreciable crushing of the strips, as the sliding way has considerable rigidity. The excessive bending moment on the sliding way may be relieved by cambering the last few feet of the groundway.

CONTROL OF BUILDING BRICKS.—With a view to encouraging the industry to increase the output of bricks to meet the prospective demand, it is the intention of the Minister of Munitions, provided the present system of control continues, to maintain the present controlled maximum prices for a period of six months from January 1, 1919.

THE LOSSES OF THE NORWEGIAN MERCHANT MARINE DURING THE WAR.—According to the figures so far available the losses of men and ships of the Norwegian merchant navy from the commencement of the war until the conclusion of the armistice between Germany and the Entente, are as follow: 831 Norwegian vessels have been lost, with an aggregate tonnage of 1,238,297 registered tons gross. Of this total, 652 were steamers and motor vessels with an aggregate tonnage of 1,043,624 tons and 179 more sailing vessels with an aggregate tonnage of 194,673 tons. Of the steamers, at the time of the loss, 32, with an aggregate tonnage of 48,663 tons, were requisitioned by the British Government. About 1,120 lives have been lost through war casualties, in addition to which a considerable number of seamen have been wounded by the attacks. In addition to the above, 33 vessels with an aggregate tonnage of 68,988 tons have been damaged, some of them seriously. The Norwegian merchant navy on October 1 comprised 3,266 vessels with an aggregate tonnage of 1,872,051 registered tons gross. During October the number of vessels was increased by six, but the aggregate tonnage decreased by 7,396, so on November 1 the figures were 3,272 vessels with a tonnage of 1,864,655 tons.

CO-OPERATION IN ENGINEERING AND ALLIED TRADES.

DURING the period of transition from the manufacture of war material to ordinary trade, some difficulty may be experienced by firms having more orders on their books than they can readily deal with, whilst there will be other firms having manufacturing facilities without orders to execute. In the national interests, it is essential that firms in these two categories should be brought into intimate touch as rapidly as possible.

With this object in view, manufacturers in the engineering and allied trades who need the assistance of sub-contractors and who meet with difficulty in finding suitable firms to undertake their sub-contracts are requested to communicate with the Superintendent Engineer of the Ministry of Munitions in the area concerned. Similarly, manufacturers having capacity available with the necessary labour should notify the superintendent engineer of their area.

The superintendent engineers will give every possible assistance to manufacturers in overcoming difficulties which may arise during the transition from war to peace manufacture. A list of the superintendent engineers and the addresses of the area offices is appended.

Department of Engineering.—List of Superintendent Engineers.

Area No.	Name.	Address.	Telegraphic Address.	Telephone Number.
1	Mr. G. H. Clay	Pearl Buildings, Northumberland-street, Newcastle-on-Tyne	Munarea, Newcastle	3814 Central.
2	Mr. H. C. Buckmaster	70, Spring-gardens, Manchester	Munarea, Manchester	8740/8 City.
3	Mr. H. C. M. Austen	Quebec Chambers, Quebec-street, Leeds	Munarea, Leeds	5500 Leeds.
4	Mr. A. A. Howse	111, New-street, Birmingham	Munarea, Birmingham	2700 Midland.
4E	Mr. G. S. Knocker	91, Queen's-walk, Nottingham	Munarea, Nottingham	5578/9 Nottingham.
5 & 6	Mr. Selwyn Grant	3, Unity-street, College-green, Bristol	Munarea, Bristol	5090 Bristol.
7	Lt. Moberly	Room 114, Charing Cross Buildings, Embankment, W.C. 2	Mundepeng 'phone, London	Gerrard 540. Ext. 712.
8	Mr. G. Davidson	90, Princes-street, Edinburgh	Munarea, Edinburgh	9040 Central.
9	Mr. W. D. Kirkwood	39, Elmbank crescent, Glasgow	Munitions, Glasgow	9880 Central.
10	Captain C. Ablett	32, Nassau-street, Dublin	Munarea, Dublin	4894/6 Dublin.
11	Mr. A. W. Brown	Coates Buildings, Castle-street, Belfast	Munarea, Belfast	578 Belfast.

PROPOSED ROAD IMPROVEMENTS.—The normal work of the Road Board, which was to a very large extent suspended during the war, is to be resumed forthwith. Owing to the lack of materials, transport and labour the ordinary renewal programmes of the highway authorities have not, in the immediate past, been carried out in the case of a large mileage of roads. In some cases the authorities have carried forward the sums which but for the war they would have expended on the roads, whilst in other cases the opportunity was taken to reduce the rates in the hope, which we trust will not be justified, that aid will be refused to those who can be shown to be in no immediate need of funds and given to the less thrifty. Owing to the rise of prices the work to be done in restoring our roadways will cost much more than similar work in pre-war times. In view, however, of the urgency of this work and of the desirability of finding employment for demobilised men, it has been decided to distribute 10,000,000*l.* amongst the highway authorities for the benefit of the roads. Of this, 8,250,000*l.* will be found by the Exchequer, whilst 1,750,000*l.* will be contributed from the Road Improvement Fund. The Road Board will be charged with the administration and distribution of this grant. No highway authority will be entitled to a share unless they submit a statement showing that they are arranging to execute out of their own resources at least as large a programme of road work as in 1914. The Road Board state that it is desirable that the bridges on important roads shall be put in a fit state to carry heavy motor traffic and are prepared in approved cases to contribute one-fourth of the cost of such work as may be undertaken. The roads and bridges for which grants will be made will be selected by the Road Board in consultation with the local highway authorities. In some areas there are certain "District" roads which the authorities concerned are anxious to have declared "Main" roads, but have up till the present been unable to put into such a condition as would justify the county surveyor in granting the necessary certificate. The Road Board suggests that some of these roads may be suitable for reconstruction with the aid of the grant now proposed.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Even were no other business available it would almost seem as if the production of the steel required for the shipbuilding yards alone would keep the steel works in the West of Scotland fully occupied for some considerable time to come, the prospects in the Clyde yards, perhaps, having never been brighter. Without doubt the quantity of steel which will be needed for the constructional and repair work now on hand, not to mention the new contracts which are being booked almost daily, will make very serious demands upon the resources of the manufacturers when taken in conjunction with the wants of constructional engineers, boiler-makers, &c., who are also looking forward to an era of much business activity and prosperity. Plates and sectional bars are in great request and just as in the busiest days of the war everything produced is speedily absorbed. Steel-makers have quite a number of Government contracts still to complete, even although many of the orders, such as those for shells have already been cancelled. In accordance with the expressed desire of Government, and despite the fact that the export markets are much in need of supplies, no shipments will be permitted until the wants of the home consumers have been fully met. Some difficulty is still being experienced at the steel works owing to the shortage of the coal supply, but with the release of miners from military service this should very shortly be overcome. The uncertainty of the future is a disturbing element to some minds, yet with care and judgment the readjustment may be safely overcome and the tide successfully weathered. Pressure for delivery is an outstanding feature of the steel trade at the moment.

Malleable Iron Trade.—While gradually slacking off from war work, malleable iron makers continue to be very busy and are well booked up with good orders from ordinary mercantile consumers who have had little consideration during the past four and a half years. The transition period will be one of some difficulty; one contributory reason is the present shortage of skilled labour, another the fact that the advance of export rates has practically put out of court any hope of good overseas' orders meantime. Would-be consumers are content now to "wait and see," they are certainly unwilling to do business at the present figure, and feel that 20*l.* per ton for bar iron is just a trifle stiff. It is mooted in reliable circles that were natural conditions allowed to prevail, Scotland's lost supremacy in the manufacture of malleable iron might speedily be regained.

Pig-Iron Trade.—Considering the activity in the steel trade it is not to be wondered at that there is such a brisk and increasing demand for pig-iron of all grades. In every case the home consumer is getting the preference, the smelters showing little or no disposition to undertake overseas orders meantime. Some small lots, therefore, represent the shipments abroad, although constant inquiries are coming in from practically every quarter of the globe. The fact that subsidies will not be removed until the end of April has an influence all its own and reflects upon the business put through.

Clyde Shipbuilding Figures.—In connection with the reissue of the quarterly returns of merchant shipbuilding made by Lloyd's Register of Shipping, it is interesting to note the position taken by the Clyde yards. During the quarter ending September 30, there were under construction in the United Kingdom 383 merchant vessels of a gross tonnage of 1,746,953. Of these, 78 vessels were being built in Glasgow and 50 in Greenock, the former responsible for 331,008 tons, the latter for 271,080 tons. These figures, of course, do not include any Admiralty work.

NON-FERROUS METALS SUSPENSION ORDER.—The Minister of Munitions has suspended until further notice the following Orders: The Copper (Sale or Purchase) Order, 1916, which prohibited dealings except by special permit. The Copper (Use in Manufacture) Order, 1916, which prohibited use in manufacture except for orders within Class A or B priority. The Copper (Control) Order, 1917, which took possession, with certain exceptions, of all unwrought copper, including copper scrap and swarf, and also required returns. The Brass and Copper (Returns) Order, 1916, which required returns of output of brass or copper rod, tubing, sheets, &c. The Brass (Swarf and Scrap) Control Order, 1917, which took possession of (*a*) all yellow brass and cartridge metal swarf turnings and borings, (*b*) all yellow brass scrap resulting from the manufacture of war material, and also required returns. The Cupro-Nickel Scrap (Dealings) Order, 1917, which prohibited dealings except under licence. The Spelter (Control) Order, 1917, and the Spelter Control (Amendment) Order, 1918, which prohibited dealing, &c., or use in manufacture except by licence and required returns of stocks, &c. The Lead Order, 1917, and the two Lead Control Amendment Orders, 1918, which took possession, with certain exceptions, of all pig lead, scrap lead and lead residues; prohibited purchase or sale, &c., or use in manufacture except by licence; required returns, and fixed maximum prices for such lead, manufactured lead, lead compounds, and used type metal. The Type Metal (Returns) Order, 1918, which required returns of stocks from persons having more than 1 cwt. The Minister of Munitions has also suspended until further notice the Tin (Dealings) Order, 1917, and the Tin (Dealings) Order, 1918, which specified tin as war material and prohibited dealings &c., or use in manufacture except by permit and required returns. The Minister of Munitions has, further, suspended the Chrome Ore Order, which prohibited dealings except under permit.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—There is small prospect of cheap prices in any sphere in the immediate future. On the contrary, rates of raw and manufactured material alike show signs of considerable advance. The plan adopted by the Government of subsidising makers to cover increase of cost in the matter of fuel and wages has resulted in an uncertainty and confusion as to the future of the trade, which has brought the steel market almost to a standstill. The withdrawal of the bounties on coke, basic iron billets, and finished steel on the cessation of hostilities would have caused such a sensational upward movement as to be impossible. An arrangement has accordingly been arrived at by which the steel subsidies will come off on January 30, and those on pig-iron three months later. New prices have been fixed for steel as from January 30. Soft basic billets are advanced for the home trade from 10*l.* 7*s.* 6*d.* to 11*l.* 12*s.* 6*d.*, and hard basic from 11*l.* to 12*l.* 15*s.* As pig-iron will have to go up on May 1, there is every prospect on that date of a still further advance in steel. Sheffield manufacturers view the new control of the importation of raw and semi-manufactured materials recently adopted by the French and Italian Governments with grave anxiety. It provides that users of high-speed and crucible steel, in common with other materials, must submit their requirements to a bureau, whose duty it is to arrange for their supply from home sources. Consumers are debarred from placing their orders abroad. Both France and Italy during the war were assisted by our Government to develop the manufacture of such special steel as they had been importing from Sheffield, and now it is found the new works are equal to peace-time consumption, and there will be no necessity to buy from abroad. Local firms who have for years enjoyed the considerable and valuable business connections with both the above countries are hardly hit. In many cases orders were in course of execution, and it is gratifying to know that arrangements have been made whereby the scheme will be suspended until such orders and contracts have been completed. A substantial amount of new work has come to hand during the week, and once the holidays are over good employment and steady business is assured. In most cases an extended vacation will be taken. Not only are the men in want of a long rest to recruit their exhausted energies, but in most of the big works extensive repairs and replacements are necessary. From 13 to 14 days holiday will be the rule. Prospects for the New Year are favourable. Enormous inquiries are to hand for the heavier classes of steel, such as railway material and forgings. The call for crucible steel also continues steady and substantial. For engineers' small tools, farm implements and parts, and all classes of tools used in building and excavation, the demand is enormous. Railway and shipping requirements are also of a heavy scale. The overseas demand is steadily increasing, and would be higher but for the scarcity of shipping space.

South Yorkshire Coal Trade.—The general situation remains unchanged. No falling-off is noted in the demand for inland consumption. Best steam hards continue to be difficult to obtain, with home consumers pressing for supplies. The shortage in tonnage has caused a check in the consignments from Yorkshire pits to Hull during the present month, to enable more ample supplies to be available for inland use, both for manufacturing and household purposes. Cobbles and nuts are firmly held, and here, again, consumers are experiencing difficulty in obtaining tonnages. The demand for gas fuel is exceptionally strong. Many of the works are extremely short of supplies, and their reserve stocks sadly depleted. Slacks show an easier tendency due to the smaller demand from the cotton industry. Quotations:—Best branch handpicked, 27*s.* to 28*s.*; Barnsley best Silkstone, 27*s.* to 27*s.* 6*d.*; Derbyshire best brights, 25*s.* to 26*s.*; Derbyshire house coal, 22*s.* 6*d.* to 23*s.* 6*d.*; best large nuts, 22*s.* 6*d.* to 23*s.* 6*d.*; small nuts, 21*s.* 6*d.* to 22*s.* 6*d.*; Yorkshire hards, 22*s.* 6*d.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* 9*d.* to 22*s.* 9*d.*; best slacks, 18*s.* to 19*s.*; seconds, 16*s.* to 18*s.*; smalls, 13*s.* to 14*s.*

THE FUEL SHORTAGE IN GERMANY.—There has for some time past been a pronounced shortage of fuel in many parts of Germany, and various steps have been taken or are under contemplation to bring about a more rational distribution and an increased economy. With a view to the attainment of the former end the deliveries now take place according to what may be called an urgency scale containing four sections. All four sections or grades are to be supplied for as long a period as possible. The first grade comprises those purchasers who under all circumstances must have their full supply; then comes grade 2, &c., and none of the four grades may receive a larger quantity than that allotted to them. Works which have not been classified as being of military importance have hitherto had the greatest trouble in getting fuel, a state of affairs which tended to deteriorate rather than improve, and no remonstrances have been of any avail. The concerns doing war work were supplied with fuel, even under the most pronounced rolling-stock famine, the result being that the former in many cases had to decrease their output. For domestic purposes also the supplies have been inadequate. With a view to possible emergency the Rhenish Lignite Syndicate has accumulated fair stocks, which now come in handy, and the supply of lignite briquettes from the Rhenish districts have been fairly satisfactory, whilst the deliveries of lignite briquettes from Central Germany have been very short. By way of economising it has been proposed to reduce the lighting in Berlin, and to reduce all traffic.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—A welcome further step is announced in the direction of removal of official control, the intimation being made that priority certificates will no longer be required. Licences for export are, of course, still necessary. There appears to be no movement in the way of sanctioning shipment to neutrals, the needs of home customers and of the Allies being still too urgent to permit of exports to neutrals. Home demand is very heavy and deliveries would be large but for difficulties of distribution. On the other hand, shipments are light. The great bulk of the loadings are for France, but even to French ports shipments are on a reduced scale, and December clearances promise to be very meagre. For home consumption, No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge all stand at 95*s.* and No. 1 is 99*s.*; whilst for export, No. 3 and the lower qualities are 145*s.* and No. 1 is 150*s.*

Hematite Iron.—There is not a great deal to complain of as regards the East Coast hematite branch. Supply, though by no means plentiful, cannot be said to be unsatisfactory under the conditions prevailing. Urgent home needs are checking, to some extent, shipments to the Allies, but subject to difficulties of transport, works here are receiving regular supplies, Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, and 172*s.* 6*d.* for export.

Foreign Ore.—Buyers of foreign ore are a good deal in evidence notwithstanding consumers' considerable stocks and the fact that imports against current contracts are coming forward well. The large inquiry, however, does not result in a great deal of new business, but a feeling prevails that after the holidays expansion of trade may occur.

Coke.—Coke, generally, is very scarce, but the heavy needs of the blast furnaces continue to be wonderfully well met, though some firms are receiving supplies from hand to mouth. As is usual before the Christmas holidays consumers are pressing greatly for delivery. Average furnace coke is 33*s.* at the ovens, and quality low in phosphorus 35*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—There is very great activity in finished iron and steel. The transition period is not without its difficulties, but the principal firms have adapted themselves well to the altered conditions. Wholesale cancellation of Government orders has left them free to accept long overdue other business which is now offering in immense volume, and the outlook is regarded as bright and encouraging. Urgent needs of the shipyards, requirements of the railways, and demand for constructional steel are providing plenty of work. To home customers principal quotations stand:—Common iron bars, 14*l.* 10*s.*; steel ship, bridge and tank plates, 11*l.* 10*s.*; steel angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; chequer plates, 13*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy steel rails, 10*l.* 17*s.* 6*d.*; and steel billets, 10*l.* 7*s.* 6*d.* to 11*l.*; and for export the following are among the principal market quotations: Common iron bars, 20*l.*; steel ship, bridge and tank plates, 16*l.* 10*s.*; steel angles, 16*l.* 2*s.* 6*d.*; steel boiler plates, 17*l.* 10*s.*; chequer plates, 18*l.*; steel joists, 16*l.* 2*s.* 6*d.*; heavy steel rails, 15*l.* 10*s.*; and steel billets, 13*l.* 10*s.* to 15*l.*

TRANSPORT INDUSTRIAL COUNCIL.—The Motor Transport Employers' Federation, with Major-General S. S. Long, C.B. (Lever Brothers, Limited), as chairman, and a very strong Central Council, representative of the various trade interests throughout the country, is actively interesting itself in the establishment of a Joint Industrial Council for the transport industry on the Whitley Report. It is recognised that the conditions of industry that now appertain at the conclusion of hostilities necessitate harmonious co-operation between those who organise and those who carry out the operations, and the transport industry being vital to the prosperity of nearly every other industry should be among the first to be organised. Any owner of a goods-carrying commercial motor vehicle is eligible, and a copy of the prospectus can be obtained from Captain F. G. Bristow, General Secretary, Motor Transport Employers' Federation, 83, Pall Mall, London, S.W. 1.

THE CRYSTAL STRUCTURE OF ICE.—The X-ray study of the crystal structure of ice by A. St. John (Proceedings of the National Academy of Sciences of the United States, July, 1918) was rendered difficult by the fact that the rays tend to melt and to sublime the ice. In a first attempt to turn the difficulty the whole system was encased and cooled by ice and salt; later a small ammonia machine was used which stopped the melting but not the sublimation of the ice; finally the crystals were encased in gelatin capsules, in which they could be preserved for days. The isolation of a crystal also caused difficulties. The prismatic commercial ice consists of distorted crystals which proved unsuitable for examination; from a layer of ice 2 mm. in thickness, produced by pouring water into a pan, individual crystals could hardly be extracted; finally ice was frozen out of a weak salt solution which yielded crystals with distinct cleavage planes. The crystals were found to be hexagonal, as is generally assumed, and could be referred to four inter-penetrating triangular space lattices, and to two axes meeting at an angle of 120 deg. and a third axis vertical to the former. The side of the elementary triangle was found to be $a = 4{\cdot}74$, its height $h = 6{\cdot}65$, and the spacings between the planes in the crystal in the three directions were $d = 2{\cdot}27$, $2{\cdot}37$ and $3{\cdot}32$ respectively—all these dimensions being in 10^{-8} cm. units.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—There continues to be an acute shortage of coal on the market, and shipments, although fairly heavy, have had to be restricted. Inquiries are plentiful and pressing, but practically no coal is now released for shipment on private account. During the past week vessels have been waiting for supplies, but the desired quantity of coal is not forthcoming. The arrangement made for a cessation of work at those places where there was a contested election last Saturday naturally had the effect of curtailing outputs, but hardly to the extent feared. The arrangement come to was loyally observed, taking the coalfield generally, and in some districts the men volunteered to continue at work notwithstanding that they could have taken the day off. Satisfaction is expressed, too, that the miners have only asked for two days' holidays at Christmas, and if work is generally resumed on the Friday, then the effect will not be as serious as has been expected. A good deal of coal—more than the average quantity—has been allocated for inland consumption. Sailings have been quite heavy, and tonnage has been diverted to other places with the result that to-day there was less congestion at the local docks than has been the case for some time past.

Newport.—Shipments of Monmouthshire coals have been quite active, but vessels are still waiting for cargoes. Increased quantities of coal are being reserved for home consumption, particularly for the use of railways. The greater part of the outputs of the Eastern and Western Valleys is now being allocated for inland trade, but despite this arrangement the shortage of coking smalls is acute. In the case of one or two undertakings it is stated that they are almost obliged to stop owing to the need for certain classes of coke, and they are pleading with the authorities for immediate deliveries.

Organisation of Coal Exporters.—There was a large attendance of coal exporters yesterday when the foundations were laid of a South Wales Coal Exporters' Association. The project has received the support of many of the most influential firms, and the initial proceedings yesterday were presided over by Mr. T. J. Callaghan, president of the Cardiff Chamber of Commerce, and the first ten subscribers were empowered to act as a provisional directorate pending the completion of the necessary registration formalities. An impetus has been given to the movement owing to the proposed Italian State monopoly of coal imports, it being felt that it was now essential that coal exporters should band themselves together in order to give collective expression to their views, and to take concerted action in the defence of their interests.

New Coal Board Chairman.—At a meeting of the Board of Conciliation for the Coal Trade of Monmouthshire and South Wales, held at Cardiff yesterday, it was announced that the Coalowners' Association had unanimously decided to appoint Mr. Evan Williams as the chairman of the owners' side of the Board, in succession to Mr. F. L. Davis, who had resigned. The announcement met with general approval, and the Miners' Federation president (Mr. James Winstone), on behalf of the workmen's representatives, paid a cordial tribute to Mr. Williams as to the latter's fitness for the post. Though largely interested in the coal industry, Mr. Williams can hardly be said to be one of the magnates of the coalfield. While presiding over various committees, however, he has displayed conspicuous ability and tact in the conduct of negotiations, so that he was marked out for the well-deserved compliment now paid him. Mr. Williams presided over the committees dealing with the numberless issues arising out of the passing of the Minimum Wage Act, while during the period of the war he has presided at the weekly meetings of the Disputes Committee of the Coal Board—a machinery which was set up to deal expeditiously with disputes and prevent colliery stoppages—and he has had, therefore, a training which specially qualifies him for the discharge of the duties which will devolve upon him in the important position which he is now called upon to fill. The position carries with it a salary of 2,000*l.* per annum.

FLOATING ELECTRIC POWER STATION—ADDENDUM.—In the description which we gave on page 644 of our issue of December 6 of the floating electric power stations built to the order of the Department of Inland Waterways and Docks, we omitted to state that the builders of the barges themselves, and the contractors for the boiler-room equipments, were Messrs. R. and W. Hawthorn, Leslie and Co., of Newcastle-on-Tyne. There is no doubt that the experience of this well-known firm of marine engineers and shipbuilders contributed largely to the success of these floating power stations.

STOCKS OF NON-FERROUS METALS.—In order that the trade may know the position in regard to stocks of the important metals, the following particulars are published of the stocks (exclusive of old metal and scrap) in this country in the possession of the Minister of Munitions on December 1, 1918, viz.: Copper, 27,530 tons; spelter, G.O.B., 18,768 tons; spelter, refined, 6,544 tons; aluminium, 10,215 tons; soft pig lead, 49,111 tons; nickel, 1,735 tons; antimony regulus, 3,303 tons. It is intended to publish, at monthly intervals, the stocks held on the first day of each month. In addition to the above the Minister holds large quantities of scrap, mainly brass, of which it is impossible to give any figures at present.

THE ARMISTICE AND THE WEST GERMAN IRON INDUSTRY.

THERE is much misgiving in Germany as to whether any goods traffic can take place between the left and right banks of the Rhine, even supposing it to be possible concurrently with the return of war material and troops. The cessation of the traffic means that the works on the left side of the Rhine will barely be able to receive the adequate amount of fuel from Rhineland and Westphalia to keep them going. A supply of coal and coke could only be obtained from the Saarbrücken district. In Luxemburg the shortage of coke has already necessitated the closing down of a number of blast furnaces. At the same time the supplies of ore from Lorraine and the Longwy and Briey districts will no doubt come to a stop, which will seriously embarrass the Westphalian iron works. Much concern is felt in the huge mining and iron works to the north-west of Metz, which were mostly in full swing and which have now passed undamaged into the hands of the Entente. The German shareholders, remembering the high-handed treatment of Belgian works of a similar character, are feeling very anxious. The south Alsatian textile industry was to a much greater extent under the control of the French, or of French sympathisers. The condition of the iron industries in the vicinity of Metz is repeated in the large Westphalian undertakings in Luxemburg, at Esch, Rümelingen, &c. Further south the occupied districts comprise the mining and iron industries of Saarbrücken, Dillingen, Neunkuchen, &c. East of Lorraine numerous busy towns and hundreds of limited companies will be affected in a manner which may have far more than local effect. Suffices it to mention steel works like Krupp, Becker, Zypen-Wissen, &c., the large machine works, motor and powder factories in Rhineland, the left Rhine coal, lignite, iron and zinc ore mining concerns, electrical and cable works, chemical and textile undertakings, &c.

RENEWED SHIPPING SERVICES FOR VLADIVOSTOCK.—We read in *The London and China Telegraph* that the possibility of an early renewal of regular communication by railway with the interior of Siberia has attracted the attention of the shipping world again at Vladivostock. The various steamship companies that formerly operated regular steamers between Vladivostock and Canadian and United States ports are considering the re-establishment of their services. The Canadian Pacific Railway is advertising the sailing of a steamer from Vladivostock for Vancouver. It is understood that if the business offering is maintained, this steamer will make Vladivostock a regular port of call, and that other steamers of this company will be sent to the port from time to time. The Robert Dollar Company is re-establishing its Vladivostock service by having a steamer call at the port on its eastbound trip from China. It is expected that the Blue Funnel Line of the Ocean Steamship Company will also have a steamer calling at Vladivostock as soon as one is available. With these three lines and the probability of other companies also entering the field, regular and frequent steamship communication between Vladivostock and the Pacific ports of Canada and the United States should soon be re-established. The Nippon Yusen Kaisha has announced the intention of again operating its Vladivostock–Kobé service, which was discontinued last year. Probably the Osaka Shoshen Kaisha will also add to its present weekly service with Tsuruga by establishing regular sailings between Vladivostock and other ports in Japan. These Japanese services make possible the utilisation to a greater extent of the regular trans-Pacific lines for the shipment of merchandise to Siberia, the goods being transhipped at Japanese ports.

A FLIGHT FROM CAIRO TO DELHI.—On page 688 of our last issue we gave a very brief account of a flight in a Handley-Page aeroplane, from Cairo to Baghdad, made by Major-General Salmond, R.A.F., Brigadier-General Borton, R.A.F., and Captain Ross Smith, A.F.C., with two air mechanics. Since then it has been announced that the flight was continued to Karachi, where the officers conferred with the Government of India regarding the organisation and establishment of the aerial route and service to India. The Handley-Page machine employed for this purpose was the one which took an active part in the final operation against the Turks on the Palestine Front. The route flown from Cairo was by way of the following stages: Damascus, Baghdad, Bushire, Bandar Abbas, Charbah, Karachi, and the whole journey from Cairo to Karachi occupied 36 hours of actual flying time. The total distance of the route followed from Cairo to Karachi is 2,548 miles. It should be noted that this flight was undertaken in the ordinary course of aerial duty, and was in no sense made against time or for record-breaking purposes. General Salmond then continued his journey by air to Delhi, where he arrived at 3.30 p.m. on the 12th inst. The amount of organisation required for this trial trip was, of course, very considerable, and it is a noteworthy tribute to the excellence of the arrangements made that no hitch of any kind occurred. Petrol, oil and spares depots were provided at pre-arranged points, and no difficulties arose to mar in any way the success of what must undoubtedly be pronounced a remarkable and historic flight, which is described by those concerned as a splendid augury for the British Eastern air service of the future. Some confusion having apparently arisen in the public mind in connection with the previous report of General Salmond's flight from Cairo to Baghdad, it should be pointed out that Major-General W. G. H. Salmond, D.S.O., the General Officer Commanding the Royal Air Force in the Middle East, and not his brother, the General Officer Commanding the Royal Air Force in France, is the officer concerned.

SINGAPORE HARBOUR WORKS; KING'S DOCK, KEPPEL HARBOUR.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, AND MR. J. R. NICHOLSON, M.M.INST.C.E., ENGINEERS.

(*For Description, see page* 702.)

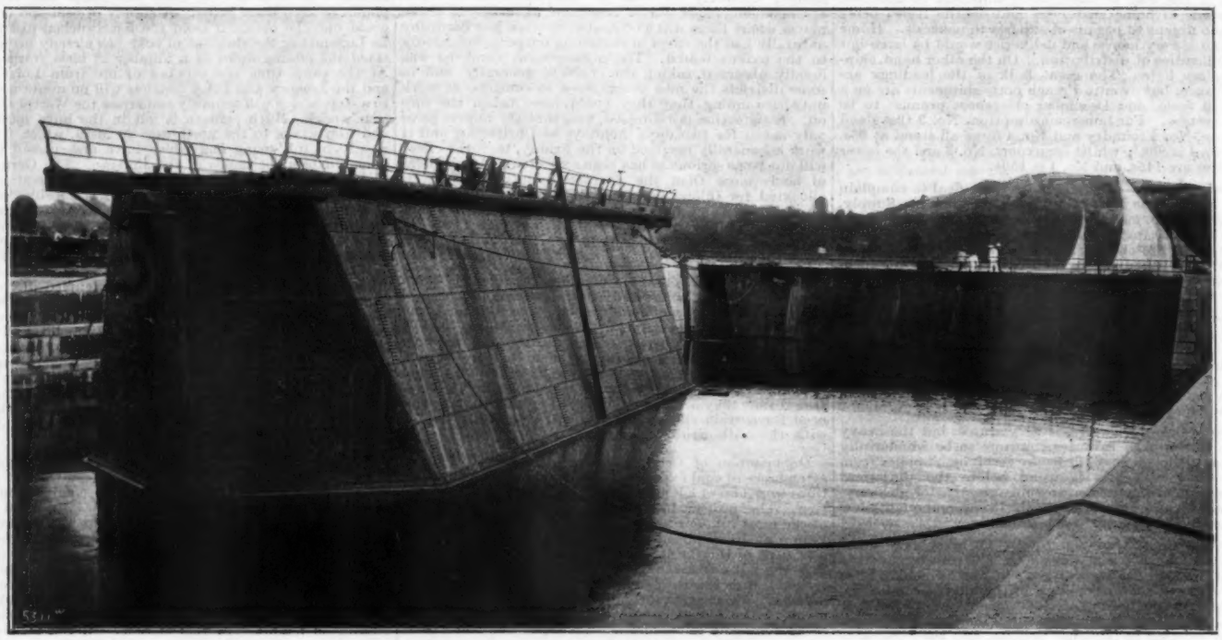


Fig. 60. The Caissons.

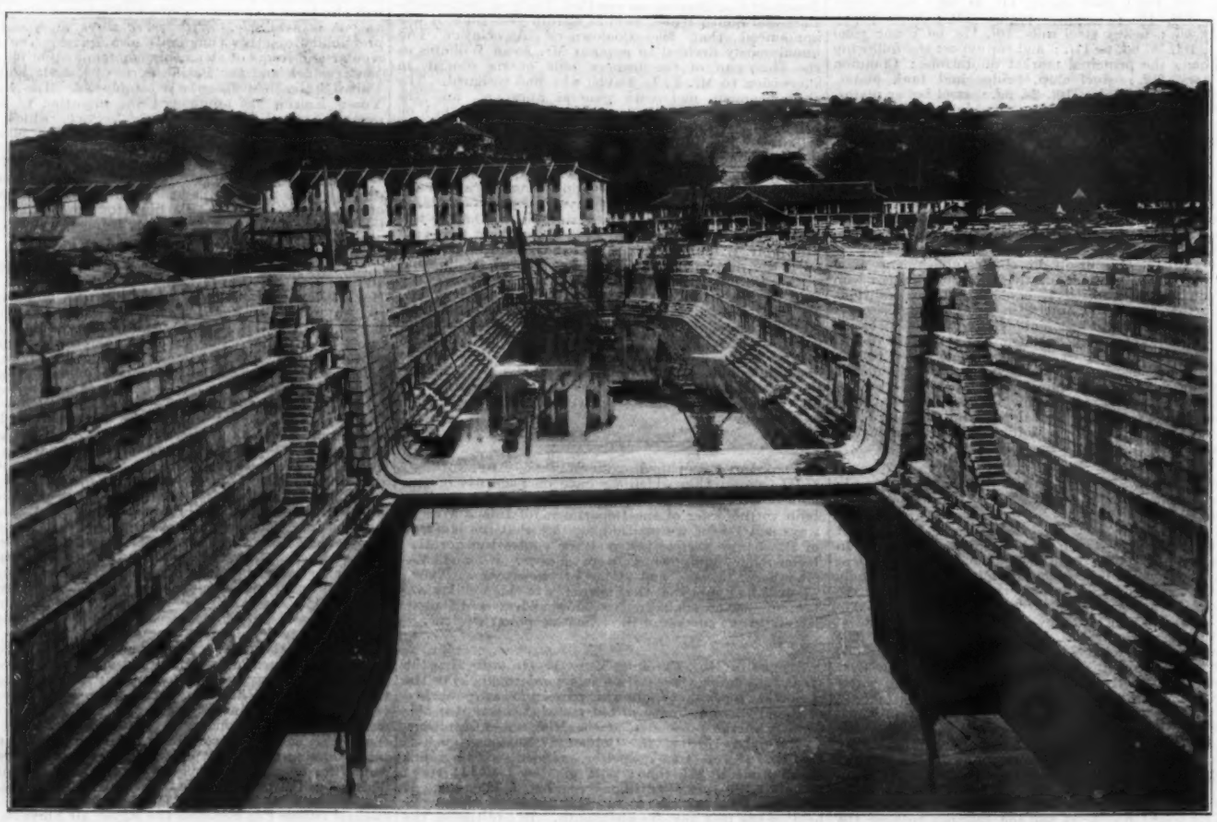


Fig. 61. General View of Dock looking towards Head.

HARBOUR AND DOCK WORKS AT SINGAPORE; THE KING'S DOCK, KEPPEL HARBOUR.

MESSRS. COODE, MATTHEWS, FITZMAURICE AND WILSON, AND MR. J. R. NICHOLSON, MM.INST.C.E., ENGINEERS.

(For Description, see Page 702.)

Fig. 42. LONGITUDINAL SECTION ALONG CENTRE LINE OF DOCK.

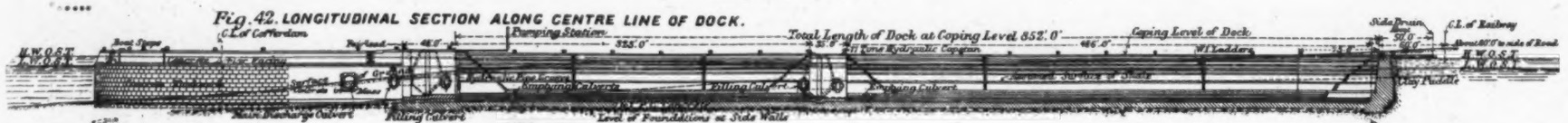


Fig. 43. ENTRANCE CHANNEL

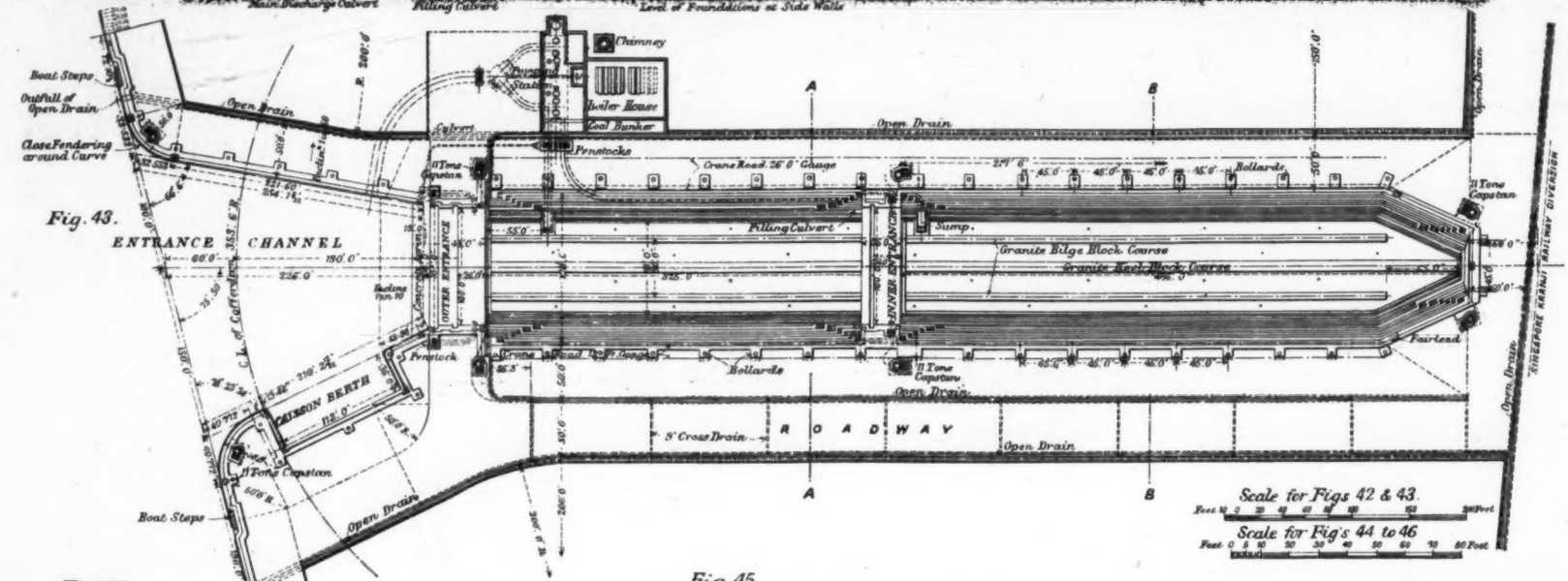


Fig. 44. ELEVATION OF OUTER ENTRANCE TO DOCK.

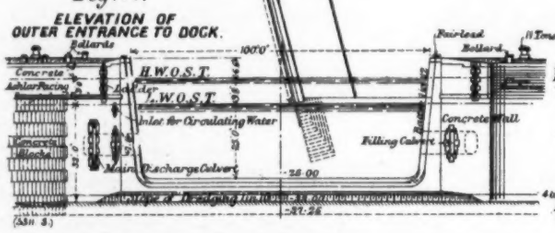


Fig. 45. CROSS SECTION A.A. SHOWING INNER ENTRANCE.

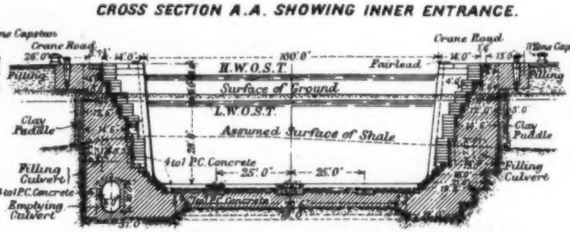


Fig. 46. CROSS SECTION B.B. SHOWING ELEVATION OF HEAD OF DOCK.

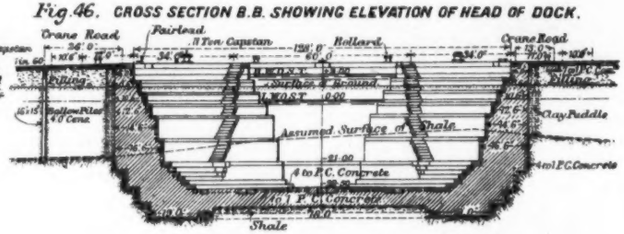


Fig. 47. LONGITUDINAL SECTIONAL ELEVATION ON CENTRE LINE OF DOCK. (OUTER ENTRANCE)

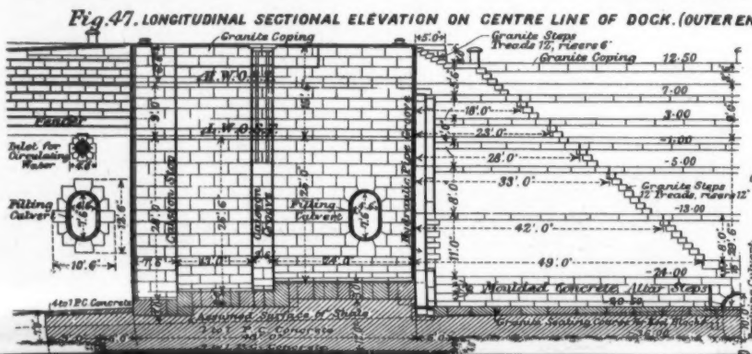
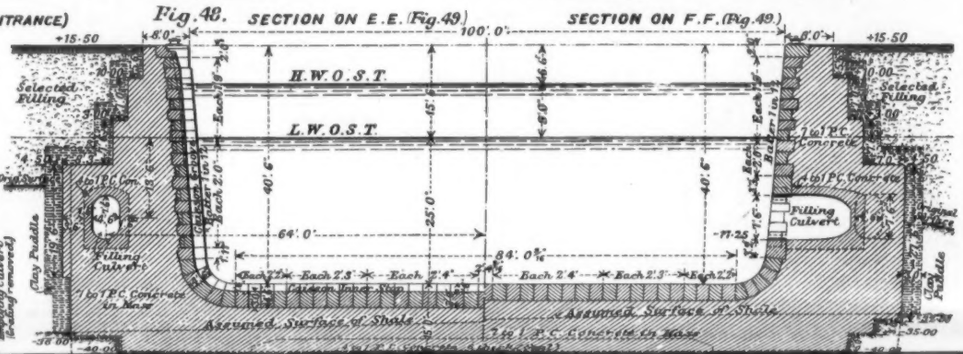


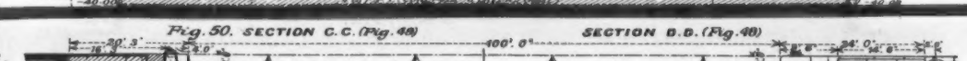
Fig. 48. SECTION ON E.E. (Fig. 49)



SECTION ON F.F. (Fig. 49.)

Fig. 50. SECTION C.C. (Fig. 48)

SECTION D.D. (Fig. 48)



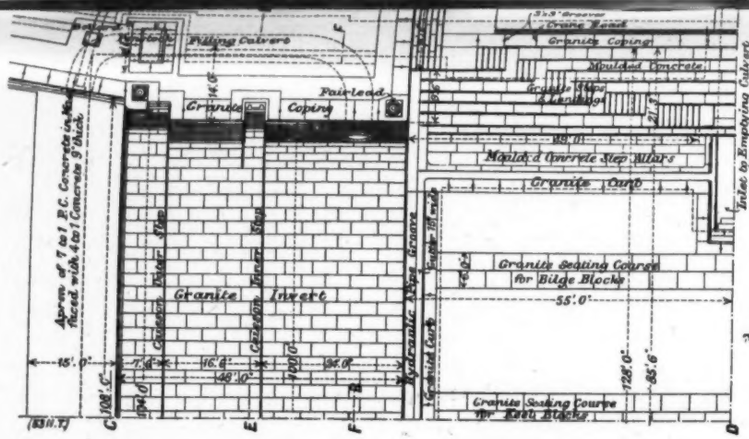
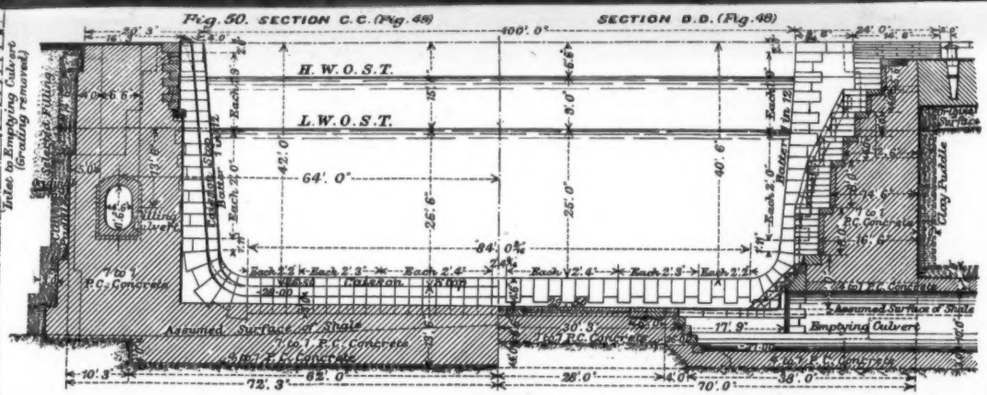


Fig. 50. SECTION C.C. (Fig. 48)



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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

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With a Two-Page Plate of the HARBOUR AND DOCK WORKS AT SINGAPORE; THE KING'S DOCK, KEPPEL HARBOUR.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

ENGINEERING.

FRIDAY, DECEMBER 20, 1918.

OUR INDUSTRIAL PROSPECTS.

WE well remember some thirty years ago that the head of one of our leading engineering colleges expressed himself as by no means in entire sympathy with a movement then active for a large increase in the number of technical schools of university rank. He observed that though the number graduating annually might be small, the supply of scientifically trained students of engineering was well in excess of the demand. Of course, had the development, in this country, of the heavy electrical industries been permitted by Parliament to proceed naturally and normally, the prospects of the technical graduate of that day might have been most materially improved. Instead of relying on other nations to do the thinking for us, we should have found openings and opportunities for many able young men of our own, to the very great benefit of the nation at large. To-day, as in 1890, there is again a popular outcry for further facilities for technical education, and it remains to be seen whether the public has learnt anything whatever by the experience it has gained during the past quarter of a century, and whether it will, to its own great advantage, see that our economic conditions and policies are such as to foster a demand for the proposed enormous increase in the annual output of scientifically-trained engineers, chemists and biologists.

Unless past practices and precedents are very substantially changed, the majority of the students from the enlarged technical schools will find it necessary to seek a career in some other field than that of our manufacturing industries. It may, moreover, be taken as certain that we shall not succeed in liquidating our enormous war debt without making the fullest possible use of such creative brains as the nation may be fortunate enough to include amongst its population. Admittedly geniuses are rare, nor will genius readily develop in inappropriate surroundings. To secure the development of one great artist requires the backing of a society in which art is pursued by many who are not great artists. Shakespeare stood supreme amidst a crowd of lesser literary lights, and George Stephenson grew up in a Northern mining area where clever mechanics were common. To ensure that the men of exceptional talent, who will be required for the recreation of the wealth destroyed during the past four years, shall be forthcoming, prospects of a reasonably successful career must be open to men of less striking abilities, who will in fact be required to attend to the indispensable, though it may be uninspiring, common round and daily task.

How in the past have the prospects of the average young engineer compared with those of his peers in other professions? Some interesting data on this head were given by Mr. W. Price Abell in his recent address to the Derby Society of Engineers.

He stated that the education of a doctor extended over five or six years and cost about 1,000*l*. After completing the course, 99 per cent. of the medical graduates have been, Mr. Abell says, certain of employment at incomes beginning at 200*l*. a year and rising to an average of 500*l*. per annum at the age of 30. One medical man in a thousand makes an income of the order of 5,000*l*. a year. The clergyman's education costs, Mr. Price Abell stated, some 300*l*. to 800*l*., and on completion employment was certain at an income ranging from 150*l*. at the outset to an average of 220*l*. a year at the age of 35. There are about 40 prizes open to clergymen bringing in incomes of 5,000*l*. to 15,000*l*. a year. A solicitor's training, Mr. Price Abell continued, costs from 300*l*. to 800*l*. to procure, and there is a 99 per cent. chance of subsequent employment at rates running from 100*l*. to 200*l*. per annum in the earlier years, with an average income when beyond 30 of 300*l*. per annum. The large prizes are more numerous than in the medical profession.

In the case of the engineer, Mr. Price Abell said that, taking both premium and non-premium pupils together, the chances for an engineer (not including of course mere craftsmen) are represented by the following table:—

	£ per annum.
1 per cent. will make over	1,000
1·5 per cent. will make over	500
4·5 per cent. will make over	300
9 per cent. (serving abroad) will make over	300
37 per cent. will make over	200
37 per cent. will make less than	200

Further, as matters stood before the war, every advertisement of an engineering post having attached to it an income of 200*l*. to 800*l*. per year, brought in over 200 applications. If, as is proposed, the output of qualified engineers is to be greatly increased, then unless conditions are very materially altered no positions will be available for the majority, and salaries for highly qualified men will be liable to fall to a limit with which even the Treasury, with its ingrained contempt for "stinks" and every kindred pursuit, might express itself as satisfied.

Experience during the past four years has very conclusively demonstrated that the accountant's so-called "non-productive" expenditure may, with great profit, be greatly increased. That our women folk have made every variety of munition, from complicated machine guns up to 9·2-in. shells, has been possible only because much more thought than ever before in the history of British industry has been expended on the study of industrial processes. In principle, if not in details, the Taylor conception of scientific management has been widely adopted. Technical staffs have been increased far beyond the proportions common in pre-war days, and this has rendered it possible to determine and instruct the operative in the most effective methods of work. Much thought has been expended in subdividing up complicated processes into a few simple elements, and each of these elementary processes could, it was found, be rapidly mastered by wholly unskilled labour. Some entirely new methods and tools have also been developed and have contributed their quota to the astonishing output of our shops during the past critical years.

For this extraordinary industrial development the aid of the skilled engineer has been a first essential. The demand for his services has been such that engineering has become for the time being perhaps the best paid of all the professions, at least so far as the average man is concerned. Many of our leaders have, of course, made great personal sacrifices—giving their invaluable services either gratuitously or at much below the market value.

Wealth has been defined as consisting of exchangeable values. At the present moment the exchangeable value of the intensified output of our factories is high in a certain limited though strictly temporary market. When this market fails, are these great engineering shops and steel works to be closed down, or is the nation prepared to consider without prejudice, or *parti pris*, whether by an appropriate economic policy it may not prove feasible to keep these great workshops nearly as active in the arts of peace as they have been in those pertaining to war?

A wise decision will need the consideration of all the factors involved in the question and not merely of those immediately obvious, such as are commonly alone considered by the materialistic school which has been predominant in the past. To the importance of the imponderables involved, Mr. Price Abell devoted much of the second portion of

his address. An illuminating commentary on the fatuousness of the ancient watchwords was published in *The Times* on October 29 last. On no point was the materialistic school more insistent than on the advantage of purchasing in all cases in the cheapest market. This maxim, as *The Times* report observes, clearly commended itself as wholly beyond dispute to the high German official who, in answer to a Polish complaint that the Huns by carrying off their machinery had paralysed their industry, smilingly said: "Gentlemen, what do you want with industry? You can get it cheaper from us."

Another favourite and oft-quoted maxim is that every nation should confine its attention to making those things for which its natural conditions are best adapted. The thesis sounds supremely indefeasible; but the human mind, no matter what Plato and his followers have asserted to the contrary effect, is quite incapable of arriving at truth by mere reflection. Unless constantly checked by a comparison between deduction and experience it arrives at the most bizarre conclusions, as was exemplified by the fantastic speculations of the mediæval philosopher or of our modern politician economists and social reformers. If in place of delightedly reflecting on the impregnable logic at the base of such a maxim as quoted above, our would-be guides would endeavour to find out how things actually do happen, the national well-being would materially benefit.

Switzerland, for example, has neither coal nor iron, and her water power is relatively expensive to develop. Were our theoreticians as right as they claim, this country should be the very last in the world to develop great engineering industries, yet she has most successfully accomplished the feat. The Bosch magneto, of which the pre-war supply to this country was valued at some 700,000*l.* annually, was produced in a district with no natural advantages, and where the population was previously almost wholly unversed in the industrial arts. The cheapest motor car in the world, again, is produced by the dearest labour, and in a country where high protective tariffs have been a settled policy for years. Instances of this kind show that it is no easy matter to say *a priori* whether or no a particular area is suitable for developing a particular trade. The truth can only be found by making the attempt.

It has now been proved, for example, that tungsten can be reduced from its ores as successfully in Britain as it was in Germany, yet our politicians maintained an economic policy which made it possible for Hunland to establish an absolute monopoly of the supply. Although the metal was extracted from ores derived from sources within our Empire, our steel makers had to take their supplies of the metal from the German monopolists, and this supply was strictly limited in quantity and subject to many restrictions as to use. The British Empire supplied the muscle and brawn by which the ore was won and transported. The high-grade work was done wholly within the Fatherland. The success with which the deficit was made good when the German source was sealed, showed that it was not want of technical ability which had prevented the establishment of the industry here.

THE POWER RATING OF INTERNAL-COMBUSTION ENGINES.

The question of the power rating of internal-combustion engines is one to which much less attention has been given than is merited by the importance of the subject. The rating of any engine depends in measure upon the characteristics of its manufacturer. A cautious and conservative manufacturer will list an engine with a fair margin of power either to prevent undue disputation under circumstances that may arise after installation, to provide for inaccuracies in measurement of power on site, or to give conditions of maximum reliability in service, and so to promote goodwill and to foster a relationship conducive to obtaining repeat orders and increase of business.

To rate an engine at too high a power will lead almost inevitably to numerous troubles, unless fortunately, the duty demanded of engine be less than the rating, which circumstance will only occasionally occur. On the other hand, an internal-combustion motor should not be rated at so low a figure that its average performance will be at considerably less than maximum efficiency. There is little temptation to adopt this latter course since not only would the engine be constrained to operate normally at considerably less than maximum efficiency but its size and weight would preclude its price from coming within desirable competitive limits.

With internal-combustion engines the curve equating power and efficiency is fairly flat between quite wide limits, and so gives the manufacturer a certain range over which to list the power output of his engines. A further consideration, especially where, for commercial reasons, a wide margin of power cannot be adopted, is the type of duty demanded of the engine. Certain types of prime movers, for instance the petrol engine for motor cars, is only called upon to develop its full power in normal running; i.e., trials and racing work excluded, for relatively short periods and very intermittently. Thus we have the rating for instance, 30 h.p. to 40 h.p.

With internal-combustion engines the power which can be continuously developed is considerably less than that which can be sustained for short periods of overload, so that an engine on intermittent loading can be rated higher than an engine at constant full load. Marine engines and to a lesser extent, aero engines may be said to operate almost continuously at full load.

With aero engines the power when flying is limited by the rarity of the atmosphere at the altitude of flight, this restricting the amount of oxygen to support fuel combustion that can be drawn into the working cylinder per working cycle.

A further factor is, that with careful tuning up under test-bed conditions, an engine can be made to develop for long periods an output that under normal conditions of working, it would be dangerous to demand for other than very short periods. This statement calls for further explanation.

The maximum power that it is safe to develop continuously with an internal-combustion motor is determined in many types, such as the Diesel engine, by the cylinder which is developing the most power. Thus in a four-cylinder engine, suppose, as may well be the case, the cylinders are developing powers in the ratio of 0·8, 0·9, 1·0 and 1·1; the engine is developing altogether a power represented by 3·8 and one of the cylinders is developing 10 per cent. overload. If with careful tuning the powers were 1, 1, 1, and 1, the engine would give out power represented by 4 without any cylinders being overloaded. If it is possible under ordinary working conditions to get conditions of power per cylinder represented by 0·8, 0·9, 1 and 1·1, it would be preferable to rate the engine at 0·7, 0·8, 0·9 and 1, or 3·4 total power, although it may develop on the test bed with absolutely satisfactory results power equivalent to 4, or some 17 per cent. above the rated power.

The foregoing conditions only operate where the quantity of air or mixture drawn into the cylinder does not constitute the limiting factor as is sometimes the case, as, for instance, with petrol engine, where the designed diameter and lift of the inlet valves are restricted to this end. Early difficulties of rating with petrol engines for motor cars led the authorities to adopt for rating and taxation a formula depending on cylinder diameter and number of cylinders, disregarding speed of revolution or length of stroke. Such a course led inevitably to increased stroke/bore ratios, high speeds of revolution, and high volumetric efficiency.

The chief difficulty on the subject of rating of engines has been in connection with the making of comparisons of weights, sizes, prices of various engines, &c. On comparing engines by two different makers of the same number of cylinders, same stroke and speed of revolution, one will have a cylinder diameter, say, of 10 in. and the other of 11 in. Whether is this difference in size due to a more cautious policy towards higher reliability in the case of the maker of the 11-in. diameter cylinder, or to higher efficiency and better design in the case of the 10-in. diameter cylinder? A very careful specification and complete trials will probably go far to supply an answer to this question, yet the factor of tuning up and the latent liability of the two engines for getting out of tune under working conditions can only be proved under actual working conditions. Other factors being equal, the engine with the cylinder of lesser diameter will be the smaller, lighter and the cheaper.

Quite recently an elaborate comparison of two and four-cycle Diesel engines was made in which the two-cycle was credited with the maximum performances attained on the test bed, as against the results achieved under normal full-load running conditions at sea, in the case of the four-cycle engine. Moreover, the power loading of the four-cycle examples chosen was conservative and allowed a very considerable margin for contingencies. With internal-combustion prime movers, and especially for marine work where full power is almost continuously called for, a small increase in speed of revolution of the propeller is accompanied by a disproportionately large increase in power, and where conditions of supervision of running, adjustment and overhaul at sea are less favourable than on land, a certain substantial margin of power is most desirable.

Whilst experience has clearly shown the consequences of the errors of the past in rating engines at too high a figure, it would be most detrimental to progress in design to impose any limit on ingenuity and to restrict in the slightest way the just rewards of increased efficiency and improved performance by attempting to formulate a standard of rating for any of the main types of engines now built, yet it were better for manufacturers to cut the price of the engine to the finest limits rather than the dimensions, and for buyers to insist on such tests as would clearly prove the ability of the engine to stand up to its work. The rating and the normal load should be less than can be maintained continuously on the test bench, by a certain percentage depending on the type of duty required, and the largest percentage should be allowed for such duty as is called for from marine engines.

THE RAILWAY PROBLEM.

Much has happened since last we exhaustively reviewed the problem of the future of railways in the United Kingdom. Then [see Engineering, August 24, 1917, page 208] we came to the conclusion that railway shareholders and employees would favour nationalisation or State financial control and guarantees. On the other hand, traders and the travelling public would probably come to the conclusion that State management would be less efficient than private ownership, while Government patronage and political influences would be likely still further to prejudice their interests. The correctness of these conclusions has since been demonstrated. The recent announcement by Mr. Winston Churchill that the Government has definitely made up its mind to nationalise the railways, caused railway stocks to be advanced in price, thereby showing that shareholders' interests are regarded as inclining towards the sale of their property to the State. Railway employees having repeatedly "tasted blood" at the hands of the State, are now wholeheartedly in favour of State ownership. On the other hand, there are numerous indications that traders and the public are awakening to the fact that commercially-run, privately-owned railways were actuated by a greater desire to give their clients the best possible service, and were generally more considerate, than are the controlled railways of to-day; and they argue from this that State railways—with State bureaucratic methods and lack of enterprise—may not be a consummation to be devoutly wished. One thing we regard as proved to demonstration, viz., that the whole facts of the situation must be set before the public in order that the Government policy and methods may be known and appreciated before the State is committed one way or the other. That so important an announcement as was made by Mr. Winston Churchill should have been the result of a casual question at a political meeting is little short of a public scandal. Surely a matter affecting so colossal a deal as the purchase of property valued at some £1,300,000,000, demands more serious treatment, even in these days when expenditure has been on so large a scale that people talk glibly of millions when a short time ago they would have hesitated

to deal in thousands. For our part, we regard what has happened during the election period as conveying a very serious warning of what would happen in the event of railways being nationalised. We have seen the concession of an eight-hours' day to railwaymen; a promise of cheaper fares, and the withdrawal of restrictions; and the statement that the Government policy was the nationalisation of railways. All this as part of the Government election campaign, or associated with it.

For our part, we feel that there has been so much Socialistic talk on the subject of the railways that it is very desirable to let the light of common-sense shine upon the question. To this end, there is a serious need of information. Some we are able to give, more especially in regard to the labour position, but much data can only be furnished by the railways—presumably through the Railway Executive Committee—or the Government. As regards the latter, it will be our object to show what is needed before any business man could form a sound conclusion on the merits of the case. One thought, however, lies on the surface; it is that between the demands of the men on the one hand, and the control of their property by the Government on the other, railway shareholders will need to bestir themselves if they are to secure general acceptance of the undoubted fact that, despite all that has happened, they are owners of a very valuable property. They and their trustees—the various boards of directors—must indicate to the public and the Government that an enterprise which before the war secured a revenue of £139,451,000 in a single year—an amount which is said to have been vastly exceeded during the war—cannot be reduced to a non-dividend paying basis, so long as there are two sides of an account to operate upon. Therefore, it is not a case for going "cap in hand" to the Government, but of demanding fair and just treatment on the basis of a publicly stated proposition.

We may first consider the labour situation. Labour has made hay during the war. This is true generally, but especially so as regards railways. Moreover, in view of the taking over by the State of the control of the railways, it was a perfectly simple matter for the trade unions to exploit the situation. For years before the war, the Amalgamated Society of Railway Servants (now the National Union of Railwaymen) and the Associated Society of Locomotive Engineers and Firemen had demanded recognition. The threatened strike of 1907 was really a question of recognition; it was not secured, but as an alternative there was established a conciliation and arbitration scheme. It was to have remained in force for five years, but the various disturbances not indirectly the result of the hot summer of 1911, gave an opening for a strike, the outcome of which was the revised (or 1911) railway conciliation scheme. This, however, did not afford the unions complete recognition, but merely opened the door to the appointment of a trade union official as secretary of the men's side of a conciliation board.

The 1911 scheme was open to revision at the expiration of three years, and in November, 1913, the men's side of practically all the conciliation boards in the country gave notice to determine the scheme, this being a necessary preliminary to agreeing to a new scheme. The notices were to expire in November, 1914, and during the summer of that year a committee of general managers of railways met representatives of the National Union of Railwaymen and of the Associated Society of Locomotive Engineers and Firemen, and succeeded in agreeing a new scheme. Then came the war and all that it involved. All parties realised that it was undesirable to introduce new machinery in the circumstances, and a truce was agreed. It was to the effect that the 1911 conciliation scheme was to remain in force, and that the men's side of the boards on each of the several railways should continue to act, but they were really deprived of power by a clause that: "It was further agreed that all existing contracts and conditions of service shall remain in operation and that no new agreements shall be made by the companies either with deputations or conciliation boards during this suspensory period." In the light of all that has happened, there is no doubt that unrest was caused by this stereotyping of conditions of service. During the war the men have ascertained the differences existing between conditions of employment on the various railways, and there have been innumerable efforts on the part of individuals and the Associated Society of Locomotive Engineers and Firemen to effect changes, despite the truce agreement. Moreover, not only did the truce render the conciliation boards impotent, but the individual companies also were deprived of all power to vary the terms of employment of their men. We do not know by which side the truce agreement was drafted, but it was the best charter ever given to a trade union. Originally terminable on six weeks' notice, it was, in October, 1915, made operative so long as the war bonus agreements lasted, and these, in turn, were to last "until notice shall have been received by the railway companies from the Government determining the present control agreement, and thereafter shall be subject to determination on one month's notice on either side." To anticipate events, we may remark that this linking-up of the truce with Government control really constituted an impossible situation. Sir Albert Stanley promised that the control should be prolonged to enable the Associated Society of Locomotive Engineers and Firemen to bring forward a request for a shorter working day—yet the granting of a shorter working day represented an alteration of conditions of service, and, therefore, a breach of the truce agreement!

As the war proceeded and the cost of living advanced, the trade unions of railwaymen appealed for a war bonus. At first a committee of general managers negotiated with the unions, the then opinion being that the Railway Executive Committee were not entitled to interfere in a matter affecting the remuneration of the employees. Indeed, even the Government declined to be financially responsible for the whole of the first war bonus, and required the railways to bear 25 per cent. of the cost out of their own funds. Gradually, however, the Railway Executive Committee constituted themselves the negotiating authority, and the war bonus (now war wages) has been progressively advanced, until to-day it amounts to 33s. per week to men of 18 years of age and over. Here is a statement of the various war bonus or war wage agreements:—

Date	Amount Granted to Adult Males, Age 18 Years and Over.	Total.
Operative.		
Feb. 1915	2s. or 3s. war bonus	2s. or 3s. war bonus.
Oct., 1915	3s. or 2s. war bonus	5s. war bonus.
Sept., 1916	5s. war bonus ...	10s. war bonus.
April, 1917	5s. war bonus ...	15s. war bonus.
Aug., 1917	War bonus converted into war wages	15s. war wages.
Nov., 1917	6s. war wages ...	21s. war wages.
April, 1918	4s. war wages ...	25s. war wages.
Aug., 1918	5s. war wages ...	30s. war wages.
Nov., 1918	3s. war wages ...	33s. war wages.

The last advance of 3s. was given under a sliding scale arrangement, which will govern future changes. The basis is the Board of Trade statistics of the increase in the cost of living, 110 per cent. being regarded as equated by a war wage of 30s. per week. This applies to the bulk of the staff other than salaried staff and shopmen. Of these, the former have been given the same bonus as the men, while the workshop staff have been given general advances similar to those awarded by the Committee on Production to employees in the engineering and foundry trades, under the agreement for periodical review of wages.

As we have already explained, the basis of the various war advances was the truce agreement, whereby conditions of service were to be stereotyped during Government control of the railways. It was in opposition to the truce that the Associated Society of Locomotive Engineers and Firemen created a situation in August, 1917. They had presented a National programme of demands, including an eight-hour day, and threatened a strike. This was the subject of a proclamation, and there was no strike. But the President of the Board of Trade gave a pledge on behalf of the Government, the War Cabinet and himself "to continue the present control of the railways for a time after the cessation of hostilities, so that there would be an opportunity afforded within one month to bring forward a request for a shorter working day while the railways were under control, and that any reasonable request for a shorter working day would have the immediate and sympathetic consideration of the Government." There can be no doubt that Sir Albert Stanley used the expression "cessation of hostilities" as synonymous with "declaration of peace." Yet the signing of the armistice was made the occasion of a demand for fulfilment of the pledge. Again, a strike was threatened; Sir Albert Stanley returned hastily to London from his electioneering, and the startling announcement was made recently that:

(1) The principle of an eight-hour day for all members of the wages staff has been conceded and is to come into operation February 1.

(2) All existing conditions of service to remain unaltered pending the decision of a committee to be set up as soon as possible to review wages and other conditions of service of railwaymen in Great Britain.

This agreement was made with the Associated Society of Locomotive Engineers and Firemen and the National Union of Railwaymen. The Government have taken upon themselves to alter fundamentally the conditions of service of railwaymen, despite the truce agreement. We believe that the railway companies and the Railway Executive Committee were not associated in any way with the negotiations, although their financial interests are so greatly involved. Moreover, the agreement refers also to wages and other conditions of service which are to be investigated by a committee. This raises the question whether the railway conciliation scheme is to be abolished. It could be of little practical use during the operation of the truce agreement. If the Government are now intent upon reviewing railway wages and conditions of service the conciliation boards will be further deprived of their functions. The trade unions have claimed the right to terminate the truce and the National Union have actually given notice of their desire to do so. They have also thrown over the amended conciliation scheme which was negotiated in July, 1914, thereby also breaking another agreement, viz., the war bonus agreement of October, 1915, one clause of which was: "Upon receipt by either party hereto from the other of notice to determine this agreement the amended Conciliation Board scheme referred to in the minutes, including notes thereto, of meetings of the parties hereto on July 8, 9, 13, 17 and 22, 1914, shall come into operation."

Sufficient has been said to show that an extremely complicated situation has been created. The Government have rashly intervened in a matter that ought to have been settled by the railway officials: their ignorance of railway conditions is apparent by the fact that the principle of an 8-hour day has been adopted, instead of a 48-hour week. If they now proceed to review conditions of service it is safe to predict that the trade unions will score. Mr. J. H. Thomas has said: "There were many outstanding questions yet to be settled relating to wages and conditions, the first of which is uniformity for all grades. This problem is rendered less difficult by the official statement that the railways are not going back to private ownership. That means that the railways will not be run for private profit—which had the consequence that some systems were starved while others were well supplied—but rather with the object of developing the country as a whole." This is all very well, but the country will do well to consider carefully whether the State or the railwaymen will have the best of the bargain if the railways are nationalised. The pre-war wages bill amounted approximately to 47,000,000*l.* The war bonus and war wage grants are estimated to cost 50,000,000*l.*, and the 8-hour day 25,000,000*l.* Vicarious benevolence of this sort should give the taxpayers pause. And the end is not yet. The National Union of Railwaymen have presented the following programme of demands:—

LEICESTER PROGRAMME OF NATIONAL UNION OF RAILWAYMEN.

1. *Hours.*—That 8 hours constitute a working day and 48 hours a working week.

2. *Wages.*—That all advances given as war increases be converted into permanent wages.

3. *Guaranteed Day and Guaranteed Week.*—That a guaranteed day and a guaranteed week be established on all railways.

4. *Overtime.*—That double time be paid for all overtime.

5. *Sunday Duty.*—(Between 12 midnight Saturday and 12 midnight Sunday.)—To be paid for at the rate of double time. Sunday duty to be independent of the guaranteed week.

6. *Night Duty* (6 p.m. to 6 a.m.).—That night duty be paid for at the rate of time and a half.

7. *Piece Work, Tonnage and Bonus Systems.*—That all piece work, tonnage and bonus systems be abolished.

8. *Mileage System.*—That on those systems where locomotive men at present work under a mileage clause, 120 miles to constitute a day's work on passenger trains and 96 miles on goods trains; all mileage over and above this to be paid for at an equivalent rate.

9. *Rest.*—That the period of rest between each turn of duty be not less than 12 hours.

10. *Hybrid Grades.*—That hybrid grades be abolished.

11. *Standard Rates of Pay.*—That conditions of service for railwaymen be standardised upon all railways in the United Kingdom.

12. *Management of Railways.*—That there be equal representation both national and local, for this union, upon the management of all railways in the United Kingdom.

The clerks, too, are indicating their intention not to be left behind in the division of spoils. The Railway Clerks' Association programme seeks to secure a general standard scale of minimum salaries, ranging from 70*l.* a year for a youth of 16 to 230*l.* for a man of 28. For station masters, agents, and the more responsible positions the Association asks for rates from 250*l.* to 1,000*l.* As to hours, they claim a working week of 38 hours for day duty, and 34 for night duty, with overtime at time and-a-half, and Sunday and holiday duty at double time. The Association also demands full recognition.

We venture to predict that the result of Government negotiations on the basis of these programmes will be most unfortunate. The companies know the strength of their individual positions and ought to negotiate settlements. They also know the financial position, a matter to which we shall refer in our next issue.

THE FOREMAN.

Men are to a very large extent the product of their environment, for while their initial bent can never entirely be overset, it is experience which moulds them. Out of the sum total of environment it is avocation which is the most dominant in the production of the finished human article. This is especially true in mechanical and engineering trades, and each subdivision hall marks the individual so that by certain peculiarities he may be recognised. Men's view points differ by reason of occupation and their precise rank. Things which to one rank in industry are negligible factors are prominent, if not dominant, in another. The skilled mechanic probably never gives a thought to the particular problems of the draughtsman; no one but the unenviable man himself troubles overmuch as to the problem of the hour of the works manager. Each in his sphere has to meet and overcome difficulties and surmount obstacles to the one common end of production.

Taking all ranks into review it is probable that the office of shop foreman affords the greatest opportunities for development while, for the same reason, his job is the most perplexing. He occupies a neutral territory intermediary between man and management, and his work is never under any circumstance a sinecure. It is a little curious that a post as shop foreman should be a blind alley occupation, there are few men whose training is more intensive or upon whose shoulders more depends. Yet the job does not seem to attract ambitious men, and few responsible producers can include experience in the capacity indicated among their qualifications; it would perchance be better in many respects if they could.

It was F. W. Taylor, of scientific-management fame, who first pointed out the facts, and since his pioneer work in well organised establishments the multitudinous responsibilities which formerly rested upon the shoulders of the shop executive have been lessened. Yet for all that sufficient remain to leave the foreman more or less the pilot of production, the most useful and the most abused of all men in mechanical factories.

Mr. Taylor once occupied the post himself, and can therefore speak with knowledge. It was the experience gained by a man of first-class mental calibre which led to the startling alterations now known as scientific management. The opportunity afforded was more or less unique, and until Taylor came upon the scene the fact that a foreman of really good type was the focal point of production went unregarded by those over him who should have been qualified to judge. Not that every foreman is a genius; most are fallible men. But the intrinsic value of their activities is immense and might be more regarded even than they now are. When Taylor began to reorganise he split the foreman into eight separate activities, and that his work can be so divided and sectionalised speaks volumes as to its complexity. Even now, while it is commonplace and usual to find well organised offices where separation of function is the rule, out in the shops may be discovered a much-harassed man supposed to be competent to care for all the various details which more scientific organisation takes from his custody, leaving him to care for the real duties of his office. In many cases he is supposed to trip every mistake, whether from textual or verbal instructions, blue print or tracing, and is held wholly responsible for any errors his men commit. Called into consultation he is supposed without question to illumine the dark places and be ready with suggestion and expedient. The position demands not merely craft or technical qualifications, but acumen and basic understanding and a quality of leading and control unmatched anywhere else in production. He works shop hours, and is regarded as a superior mechanic, although his daily duties make demands and tax his every faculty.

That so many first-class foremen are in evidence under what are now obsolete conditions of effort speaks well for human evolution under stress of necessity. The quick intelligence and instantaneous decision, together with real and cultivated understanding, place a first-class man in a category by himself. Yet most other ranks have some avenue of escape to superior position and pay, their prospects on the whole are brighter, while the foreman has to consider his post as an end in itself. Discipline and shop organisation depend absolutely upon him, and all the typed regulations do not carry half the weight that a good foreman wields by reason of his example and character. Although considered more or less as being in the category of workmen by reason of association, there is a bigger gulf between mechanic and shop executive than between office boy and commercial manager. The facts are undoubted, while the reason why the foreman does not rank higher is partly due to the fact that good foremen are usual. It is one of the strangest of things that so unenviable a position should find so many applicants.

The present troublous time has resulted to a considerable extent in a re-assessment of his value, but even so, as one of the staff he suffers the disabilities of every man of fixed salary whose pay is not in terms of production. What is really required is a better understanding of the foreman's real value, and a recognition of his right to treatment more on an equality with other more favoured members of the staff. Such treatment would be long delayed justice, and what is more to the point would serve to attract the desirable candidate who now looks elsewhere to his future. By such means the management would lose nothing and gain a deal, for it is a case where the few only are involved, not the many.

NOTES.

Complex Salts for Electrolytic Deposits.

In electro-plating and in the electrolytic refining of metals, complex salts, frequently organic (tartrates, citrates, cyanides), are often preferred to the simple sulphates, chlorides, &c., because the former solutions give smoother and more adherent deposits. The reasons are not well understood, but it is largely believed that with the complex salt the metal is not primarily deposited as ion, but that, *e.g.*, in the silver bath, containing silver-potassium cyanides, the potassium ion is liberated, and that the potassium chemically reduces the silver salt. What one does not understand is why the chemically-deposited silver should fall out more smoothly than the electrolytic silver. It has also been suggested that the complex salts themselves act as reducing agents, and Bancroft maintains that the greater the potential difference between the deposit and the bath, the less crystalline and the more amorphorus the deposit. That view is in accordance with the well-known observations that the crystallinity of the deposits generally decreases with higher dilution of the bath, but it does not agree with some experiments made by Reginald S. Dean and Ming Yi Chang, of Pittsburg University (*Chemical and Metallurgical Engineering*, July 15, 1918), who support the former view. They stirred practically insoluble silver compounds (the oxide, chromate, chloride, &c.) into water; some of these very highly diluted solutions gave coarser deposits, however, than the weakest solutions of silver nitrate. Investigating the problems further, with the aid of a Leeds-Northrup transition-point potentiometer arranged for determining decomposition voltages, they found that the decomposition voltage of the double cyanide K.AgCN corresponded to the concentration of the potassium ion, and bore no relation to the concentration of the silver ion in the bath, or to the total concentration of silver in it. Hence the deposition of silver seemed to depend upon the primary discharge of the potassium ion, and to be a secondary reaction. Yet the experiment did not appear to explain why silver chloride (practically insoluble) gave a good deposit when a little potassium cyanide was added to its aqueous solution, but not with potassium nitrate. The potassium, it is suggested, liberated in the former case the un-ionised silver present in a fairly concentrated solution, but was not able to decompose the very little silver dissolved in the latter case, reacting with the water rather than with the silver salt. The argument is hardly convincing, but it is suggested that the real purpose of the addition of the complex salt is to furnish a concentrated solution of the metal, but a diluted solution of the ion. The formation of coarse crystalline deposits is ascribed to the tendency of crystals to grow. In electrolysis an ion of silver tends to settle on the silver already deposited, but with secondary deposition that tendency does not exist, because an alkali atom is liberated which dissolves in the bath, and then deposits silver at random; thus a smooth deposit is formed, devoid of preferential growth in special directions. That silver forms a distinctly crystalline deposit on metallic magnesium is said to be due to the circumstance that the first particles of silver deposited form with the magnesium a voltaic couple, the current dissolving the bare magnesium whilst depositing more silver on the already formed crystals. To obtain amorphous electrolytic deposits, another metal (*e.g.*, potassium) should, according to Dean and Chang, therefore, be provided having a lower solution tension than the one (silver) which is to be deposited, and complex salts should be used containing the ion to be precipitated at a low concentration, such that its discharge voltage will be above that of the secondary metal.

Inflammation of Methane-Air Mixtures.

When a mixture of gas and air is ignited within a closed vessel, the flame travels through the mixture in a manner and at a rate which depend upon the nature and the proportion of the gas, the position of the point of ignition, the intensity of the means of ignition, the shape and size of the vessel, and also upon the agitation of the gas mixture. The latter factor is of importance in gas engines where turbulence may be set up during the introduction of the charge. Professor R. V. Wheeler has recently studied these phenomena in mixtures of methane and air at Eskmeals (Transaction of the Chemical Society, November, 1918, pages 840 to 859), with particular reference to the development of pressure and to the speed of the flame propagation. Using spherical vessels (machined bronze castings) of 19·5 cm. and 31·5 cm. diameters and capacities of 4 litres and 16 litres, and mixtures containing from 6 per cent. to 13·9 per cent. of methane—the lower and upper limits of inflammability are 5·6 per cent. and 14·8 per cent. of methane—he observed a maximum pressure of 6·97 atms. (above atmospheric pressure), both in the big and small vessels, for the 10 per cent. mixture. His values were lower than those of Le Chatelier and Mallard

(1883), who obtained irregular values, however, but agreed better with those of Beyling (1902), who experimented with cylindrical vessels of 42 litres and 11 litres capacities. Le Chatelier had also used cylinders of 17 cm. diameter and height, and, like Waeeler, central ignition. In spherical vessels the flame probably travels as a spherical wave; in cylindrical vessels the flame may touch some portions of the cool wall earlier than others. Wheeler found that the flame would, in the latter case, travel upward and downward at the same speed in mixtures containing from 7·5 per cent. to 12·5 per cent. of CH_4, but would travel faster upward in mixtures outside that range. The maximum pressure observed need not come up to the full theoretical pressure attainable. For apart from radiation and conduction losses of heat, the combustion products are not in thermal equilibrium. Hopkinson showed, in 1906, that the temperature round the point of ignition may be several hundred degrees higher than the mean temperature (as reduced from the pressure), owing to adiabatic compression there, whilst near to the walls the temperature was much below the mean. Wheeler's pressures first rose rapidly, then kept constant for a short period, and finally dropped off owing to cooling. The period of constancy might be ascribed to a combustion in several stages and to exothermic secondary reactions between CO and steam; but the size of the vessel is of importance in this connection, and from Wheeler's experiments, some of which were made with a fan revolving in the mixture, the constancy period seems to be due rather to the equalisation of temperature within the gaseous mass. The time of first manifestation of pressure does not synchronise with the ignition moment. There is a time-lag (as Bairstow and Alexander had shown in 1905), and disregard of this fact may account for the high flame propagations stated by Le Chatelier. Wheeler observed that when the flame travelled at the rate of 28 cm. per second in a 6·3 per cent. mixture, the time-lag (between ignition and first appearance of pressure) amounted to 0·18 second, and the maximum pressure developed within 0·348 second. That was in the 4-litre vessel. In the 16-litre vessel a flame of 15 cm. velocity took 0·423 second and 1·037 second for the two periods. Owing to this time-lag the flame will actually travel about 5 cm. in the small vessel and about 10 cm. in the large vessel before setting up any noticeable pressure, which is rather curious. The pressures were registered by means of a style fixed to a steel plate 2·6 cm. in thickness; ignition was by electric sparks.

SOCIETY OF ENGINEERS, GOLD MEDAL AWARD.—The Council of the Society of Engineers have awarded the President's Gold Medal to Mr. T. Roland Wollaston, of Corporation-street, Manchester, for a paper on "A Survey of the power By-product Problem."

ROYAL INSTITUTION.—A Christmas course of juvenile lectures will be delivered by Professor D'Arcy Thompson on "The Fish of the Sea," beginning on December 31, at 3 o'clock. Courses of lectures will be given before Easter by Professor Spenser Wilkinson on "Lessons of the War"; Professor MacGregor-Morris on "Study of Electric Arcs and their Applications"; Captain G. P. Thomson on "The Development of Aeroplanes in the Great War," and "The Dynamics of Flying"; Professor Hele-Shaw on "Clutches"; Professor Arthur Keith on "British Ethnology: The People of Scotland"; Professor Norman Collie on "Chemical Studies of Oriental Porcelain"; Dr. William Wilson on "The Movements of the Sun, Earth and Moon" (illustrated by a new astronomical model); Professor H. M. Lefroy on "Insect Enemies of our Food Supplies," and "How Silk is Grown and Made"; Mr. Charles Aitken (Director of National Gallery of British Art) on "Rossetti, Whistler and Sargent"; Professor C. H. Lees on "Fire Cracks and the Forces producing them"; Professor A. Findlay on "Colloidal Matter and its Properties"; Rev. Canon Hannay on "The Irish Literary Renaissance"; Professor H. P. Allen (Director of the Royal College of Music) on "The Works of J. S. Bach" (with musical illustrations by members of the Bach Choir); Hon. J. W. Fortescue on "The Empire's Share in England's Wars"; and Professor Sir J. J. Thomson (Master of Trinity) on "Spectrum Analysis and its Application to Atomic Structure." The Friday discourses will begin on January 17, when Professor Sir James Dewar will give a lecture on "Liquid Air and the War"; and discourses will also be delivered by the following gentlemen: Temporary Lieutenant-Colonel A. Balfour, Professor H. H. Turner, Professor J. G. Adami, Professor C. G. Knott, Mr. A. T. Hare, Professor J. A. McClelland, Professor H. C. H. Carpenter, Professor Arthur Keith, Professor W. W. Watts, Sir John H. A. Macdonald, and Professor Sir J. J. Thomson.

LITERATURE.

The New Teaching. Edited by JOHN ADAMS, M.A., B.Sc., LL.D., Professor of Education in the University of London. London: Hodder and Stoughton. [Price 10*s.* 6*d.* net.]

If one searched the annals of pedagogy it would probably be found that there never was a time when dissatisfaction with existing methods of teaching was not rife, and that every age had its advocates for change and drastic reform. Universities were founded to disseminate forms of knowledge, considered vital, but have come, in Lowell's witty phrase, to be considered "as places where nothing useful is taught." Stately colleges have risen to promote new learning, and in later times, public schools have been added to quicken systematic study on approved lines and encourage discipline. Still more recently, we have witnessed the foundation of a scheme designed to train and to educate the whole nation, to stimulate industrial capacity and activity, and to provide for the best development of the Empire. The explanation of the encouragement given to new systems that obtain vogue probably is, that educationists are the product of their age, and the schemes evolved being only suited to the periods in which they are developed, need modifications as the varying wants of the nation demand and receive more appropriate treatment. But since the object of education remains unaltered, there is no generic change, or as the editor of this volume translates the French proverb, "The more things appear to differ from the older forms, the more they are the same."

At the present moment discontent is acute. Elementary Education Acts with all the amendments that successive ministers have introduced, have not made us an educated nation, either from a literary or technical point of view. The advocates for increased attention to physical science complain that classical studies have too long and too utterly engrossed the attention of teachers, and classical authorities retort that deterioration of character will inevitably be the consequence of paying insufficient attention to the "humanities." As evidence of unrest such discussion is not unwelcome, it raises an important issue, awakens attention and compels an examination of existing defects. Taken in connection with other signs it may foreshadow a fundamental change in our methods and means of education.

In this volume there are indications of another kind of upheaval. Educational authorities of repute put forward suggestions and an amount of constructive criticism, which indicate a new departure in teaching methods. There seems to be a lurking doubt that their methods have grown antiquated and unprofitable, and that teaching is apt to grow stereotyped and lifeless. Apparently the writers, or at least the editor, recognise the difficulty of reaching the great body of teachers, and regret that those most interested do not trouble themselves about development and the technical aspects of their professional work. "Once they (the teachers) have acquired, either by training or by experimenting by trial and error on their first classes, a sufficient mastery of the practical details of their work, they are content to rest upon their oars and go through life living on their small paid-up capital of technical skill." This seems rather a harsh judgment on many excellent men and women, whose work is mechanical and benumbing. The *elite*, whose pupils are drawn from the upper forms of secondary schools, have opportunities for the exercise of ingenuity, of devising schemes that give animation to their teaching, but the majority, whose work lies in a lower stratum of the educational world, have few bright intervals to relieve a life of uniform drudgery. They have our sympathy, and throughout this book we see few indications of improving their lot. As one of the contributors remarks, "There is no royal road to the multiplication table," and certainly he would be a singularly inventive genius who could impart a fresh interest to the wearisome hours devoted to acquiring that necessary accomplishment.

As an introduction to the book, the editor presents a general view of the methods and objects of the "new teaching," and in the following chapters experts detail particular aspects of this teaching as they affect the several subjects in which each is interested. The ground covered is wide, embracing both literary and technical instruction. The classics, modern languages, geography and history, furnish sufficient examples of the former; drawing, handwork and physical training the latter. Science and mathematics come under review, and in addition there are chapters on music and on suitable training for domestic and commercial life.

It is not easy to say at what precise point the new teaching diverges from the old, but perhaps the difference may be indicated by saying that under the new *regime* more is expected from the pupil and less from the schoolmaster. The advocates of the system would object to this definition and would urge that though it is eminently desirable that the pupil should play a more vigorous part in his development, not less work, but of a different character, is required from the form-master. The difficulty consists in describing succinctly the nature of this difference. The progressive teacher is expected to vary according to individual tastes the amount of mental pabulum that he considers valuable; apparently he is to attain the goal of stimulating the intellectual activity of his pupil, by indirect means. Original investigation and observation are to be encouraged, though uniformity easy of attainment and dear to the heart of the indolent teachers, may suffer by the process. One of the contributors, indeed, urges that genuine uncompromising heuristic work should be made an essential feature in the pupil's development. Such a plan does not imply any measure of superficiality. Accuracy and breadth of information are still regarded as essential, but the process of acquiring exact knowledge must be so regulated as to reduce to a minimum the waste of time and effort. It is considered essential that a subject to be effectively treated must be presented from the standpoint of the pupil rather than from that of the teacher.

The change does not seem to be so radical as to warrant fresh nomenclature and lengthy treatment. It implies an increased earnestness on the part of competent teachers, who are few and anxious to get better results from their exertions by concentrating attention on individual capacity. It also suggests the existence of a large class of teachers who hitherto, content to take the path of least resistance and follow the unchangeable road fixed by precedent and routine, are to be urged to higher aims and greater vitality. The ability of the teacher for teaching is after all the real crux of the problem, and it is to be feared that this ability is not to be commanded. By making the status and rewards of teaching more attractive greater numbers may offer themselves, but the necessary skill and dexterity may not be forthcoming in the same measure. The class system, into which the teacher has to fit himself and his methods, tends to make teaching monotonous and uninteresting, the especial drawbacks against which Professor Adams and is colleagues are fighting. The class presents an average type and the teacher addresses himself to that type. The individual, we imagine, is neglected, but the editor urges that in teaching a class or group the master has so many types before him that he is obliged to vary his methods of presentation and offer a wider range of illustration. This is as it should be, and we hope he is right, but though the experience of the present writer lies rather in the examination than in the school-room, he has rarely observed this facility of illustration. Individual teaching is not without some disadvantages that are absent from the class system, and we are glad to read that it is a mark of "the new teaching to distinguish between the two attitudes, the individualistic and the collective, and to find a place for each."

It would be out of place to trace at any length the working of the general system in its applications to particular subjects, though some, as that on Handwork by Mr. G. F. Johnson, the editor of *Educational Handwork*, interests us as craftsmen. Others, of which Music is an example, admirably treated by Professor Buck, of Dublin, and Dr. Borland, of the London County Council, concern us only as citizens. In that capacity we are all

teachers and pupils, whether at home or in the workshop, or in recreation, and without detriment we may not neglect the advice of those who have made a study of education and have given us the benefit of their matured experience. The articles on History and Geography are of special interest, for in these subjects the teacher can enjoy a wide outlook if he knows how to substitute real teaching for the mechanical and listless communication of bare facts, or supposed facts. Mathematics and science handled by Mr. J. Strachan, Mathematical Master at Merchant Taylors School, and Professor Percy Nunn, respectively, offer greater difficulties to the teacher who is anxious to give these sciences an interest that will prove attractive to the young, while preserving the innate qualities of clear thinking and accurate performance their study is designed to promote. Traditional fetters require the teacher to carry a heavy burden. It is by no means clear whether the displacement of Euclid as a rigid text-book has been accompanied by all the good results that reformers anticipated, or whether the introduction of graphs and other mechanical devices have supplied that human interest which acts as a stimulus to hard work, and removes the wearying dullness that paralyses effort and discourages persistent industry.

The ambitious scheme now contemplated by which it is hoped to train a whole population between the ages of 6 and 18 will meet with many difficulties, and none greater than the provision of masses of teachers, capable of carrying to a successful issue the aims of the promoters. Every attempt to permeate the whole body of teachers with the necessity for increased vigour and the exercise of greater intelligence is welcome, evidencing a desire to meet the enhanced and strenuous efforts to which the profession is called. The task set before those responsible for the accomplishment of the scheme of the Minister of Education is heavy and possibly thankless, for honest well-directed endeavour will have to encounter much hostile criticism, and earnest reformers will have to justify their plans and demands to a community, little sympathetic or qualified to apprehend either the necessity or the merit of the measure by which it profits.

Sulphuric Acid Handbook. By Thomas J. Sullivan, With the Mineral Point Zinc Company, a Subsidiary of the New Jersey Zinc Company. London: Hill Publishing Company; New York: McGraw-Hill Publishing Company. [Price 12*s.* 6*d.* net, bound.]

A sulphuric-acid handbook is almost a novelty. There was, since 1883, Lunge and Hurter's handbook for Sulphuric Acid and Alkali, which in 1908 was extended into the "Technical Chemist's Handbook." But we do not know of any recent handbook devoted to sulphuric acid only, whilst the expanding uses of the acid fully justify Mr. Sullivan's venture. Like paper and soap, sulphuric acid has been suggested as one of the standards by which to measure the advance of civilisation and industrial progress; the horrors of the war exemplify one direction which the advance may take. Sulphuric acid is at all times, however, indispensable to the chemist and to chemical and allied industries, and it figures very largely in processes, the final products of which must be free from the acid and from sulphur. In all these manifold processes acid of a definite strength is required, or at any rate the value of the acid depends upon this strength, and if it were more easy to secure definite strengths by other than analytical means, there would be less need for this special handbook, which is mainly tabular and does not describe the various methods of manufacturing sulphuric acid at all.

Sulphuric acid is the hydrate of SO_3, sulphur trioxide or anhydride. The anhydride forms colourless needles, which melt at 14·9 deg. C. to an oily liquid, eagerly absorb moisture and fume heavily in air, combining with the water vapour. The ordinary sulphuric acid is the monohydrate $H_2O.SO_3$ or H_2SO_4, itself an oily liquid of density 1·839; there are also combinations of SO_3 with 2, 3, 5, &c., molecules of H_2O, there is the pyro-sulphuric acid (anhydride to water 2 : 1, so-called because prepared by heating disulphates), and all the acids mix with more water and dissolve trioxide. If the mixing were not accompanied by liberation of heat and by volume changes, the density and strength of the resulting acid could easily be calculated; but considerable heat is evolved when concentrated acid and water are mixed, there follows contraction of the compound formed, the acid has no definite boiling point, and water itself does not expand regularly with rise of temperature. Again, the acid absorbs water vapour and loses water when hot; it does not distil unchanged, and by heat a weak acid can only be concentrated to a strength of 98·3 per cent. H_2SO_4. Acids of 100 per cent. and the fuming acids (oleum) of still higher strengths have hence to be prepared by adding SO_3 to strong hydrate, and the relations between density and strength are not simple. Thus tables are needed, and it is still the custom—unfortunately, we think, though many chemists will differ — to refer the density, which is generally observed with the aid of a hydrometer, not simply to water as unit, but to some arbitrary-scale hydrometer. Two such scales have come into extended use. On the Twaddle—the name should be spelt Twaddell, we think—hydrometer scale, which is generally used in this country, every degree is equal to a difference in specific gravity of 0·005; thus if x be the specific density and y indicates the corresponding degrees Twaddle, $x = 0{\cdot}005\ y + 1 = 1 + y/200$, and $y = 200\ (x - 1)$. Hence to change degrees Twaddle into specific gravity, shift the decimal two places to the right, strike off the first figure, and multiply the remainder by 2. The advantage, if any, is that the readings are magnified by 200.

Somewhat the same advantage is obtained by the use of the Baumé scale, which still predominates in America and, oddly enough, also in Germany, though the relations are not so simple and not uniform. The French chemist Antoine Baumé dissolved in 1768 fifteen parts (by weight) of common table salt in 85 parts of water, immersed a hydrometer in the solution, called the point to which it sank 15 deg., and the point to which the same hydrometer sank in water 0 deg., and divided the interval into 15 deg. He worked in his cellar at 10 deg. Réaumur (54·5 deg. F.); but his directions were not sufficiently definite, his chemicals not pure in the modern sense, and as a result many different Baumé scales came into use; 23 were used in 1881 when Professor Chandler inquired into the matter. When the United States Bureau of Standards standardised hydrometers in 1904, practically all American chemists had, however, agreed upon the "modulus" 145, which was therefore adopted in the formula: specific gravity $s = m / (m - d)$, where m is the modulus 145, and d indicates the number of degrees Baumé at 60 deg. F. In Germany the accepted value for m is 144·3, and other differences in practice make the use of tables according to the one country confusing in the other. The American Manufacturing Chemists Association had agreed upon a set of values of degree Baumé and their H_2SO_4 equivalents in 1884; in 1904 the tables prepared by W. C. Ferguson and H. P. Talbot were generally adopted; those tables and the methods employed in their preparation (determinations of specific gravity and expansion coefficients and analyses for sulphuric, nitric and hydrochloric acids) are embodied in Mr. Sullivan's handbook. These tables are based upon the international atomic weights of the year 1904; all his new tables Mr. Sullivan has recalculated for the atomic weights of 1916 (which have remained in force since, as we have explained on another occasion), and that has been a task of very considerable labour, for various reasons. The whole advantage gained by determining degrees Baumé instead of specific gravity figures is that the observer can read, *e.g.*, 62·1 deg. and 63·1 deg. Baumé when the densities are 1·7491 and 1·7705 respectively; it would, of course, be a serious matter to interfere with old-established customs, and as we stated already, a change would hardly be approved of by most chemists. Yet the customary estimation of sulphuric acid is in itself sufficiently confusing. The Baumé scale is only available for acids up to 66 deg. Baumé (density 1·8354) containing 76·07 per cent. of SO_3 and 93·19 per cent. of monohydrate H_2SO_4; higher strengths are not expressed in that way, because the density of acids of 94·5 per cent. and 100 per cent. are practically the same. The acid of 100 per cent. H_2SO_4 contains 81·63 per cent. of SO_3; an oleum is said to contain, say, 20 per cent. of free SO_3, or 85·3 per cent. of total SO_3, or 104·49 per cent. of H_2SO_4—the last term meaning that so much monohydrate could be produced by adding the necessary amount of water. Hence manifold calculations have to be made, also as to weights and volumes.

Most of these calculations, the general introduction on hydrometers, the sections on dilution and concentrations of acid by mixing, and the tables concerning mixed acids, *i.e.*, mixtures of sulphuric acid and nitric acid, are satisfactorily treated. There are further tables on the boiling and melting-points of the various hydrates, on vapour tension, &c.; it is interesting to read that 93,000 lb. of sulphuric acid confined in a covered lead pan with an exposed surface of 1,260 sq. ft. and a depth of 10 in., had decreased in strength by moisture absorption from 86 per cent. H_2SO_4 to 52·12 per cent. in the 42 days from September 9 to October 21, 1916, and the tables on the composition of dry gases from roasting furnaces and on the conversion of SO_2 into SO_3 are welcome. Mr. Sullivan states in his preface that he has discarded some old tables of Lunge, Pickering, Knietsch, &c. The tables of flanges and flange fittings (dimensions and weights of elbows and pipes, of cast and wrought iron, steel, lead), of standard brick sizes, of metric measures, inches as decimal fractions of feet, a few mathematical tables, &c., may partly stand in their places, and the notes on fibre rope knots and how to make them, *e.g.*, are quite useful in their way. But flange fittings have little to do with the direct subject, and one would prefer to have more information on the influence of impurities (lead sulphate particularly) on density, and some information on the corrosion of iron and its substitutes by sulphuric acid in concentration plants, on the electric conductivity, and especially also on the heat of dilution and the specific heat of sulphuric acid, very important for the acid concentration by heat. The omitted tables of Knietsch would have supplied some of this information; the miscellaneous tables we have mentioned are strangely mixed with additional density tables of sulphuric acid, moreover, which seem to be late additions. As many experimental data for acids of the highest strengths, the demand for which the war has greatly increased, are still missing, Professor A. W. Porter has recently, in a communication to the Faraday Society, calculated the thermal data from the thermodynamical relations of the heats of solution and dilution and has indicated graphical methods for dealing with these problems. A future hand book may have to be arranged on different lines. But Mr. Sullivan has compiled a very useful handbook of 240 pages well printed, well bound, and handy in shape, which will make friends.

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(1) *Numerical Trigonometry.* By P. Abbott, B.A., Head of the Mathematical Department, the Polytechnic, Regent-street, W. London: Longmans, Green and Co., 1918. [Price 5*s.* net.]

(2) *Mathematical Tables and Formulæ.* By P. Abbott, B.A. London: Longmans, Green and Co., 1918. [Price 2*s.* net.]

These two little books belong to Longmans' Modern Mathematical Series, designed to remove some defects in the older text-books and to facilitate those methods of instruction that find favour with progressive teachers. Some may have difficulty in understanding what is meant by the term "Numerical Trigonometry" and fail to see the necessity of making a special and limited subdivision of very elementary principles. The author's definition that "numerical trigonometry is a term intended to include those parts of the subject which, it is thought, should form part of the mental equipment of every boy and girl," does not help much, for probably every teacher would have his own opinion of what it is desirable to communicate and of the best means of imparting that selection. Mr. Abbott advocates a scheme that enables a pupil to work mechanically in logarithms, though he may have no definite notion of what a logarithm means. Some may consider that it would have been as legitimate to have taught the solution of a plane triangle without defining a sine or a tangent. Also, the author recommends that some notion of a vector should be included in universal education. Others may regard the introduction of such a topic

as a piece of ornamental embroidery that serves no useful purpose. Mr. Abbott is quite ready to admit that authorities will show indecision in deciding what constitutes numerical trigonometry, and is willing to wait the test of experience. To one not engaged in teaching, the main difference in this course and that of other elementary treatises, is the omission of the derivation of a class of formulæ that express the sine or tangent of the sum or difference of two angles, formulæ that are chased through many transformations in the older text books.

Inasmuch as the author has included problems involving the consideration of "latitude" and "departure," we had hoped for, and should have welcomed, some information on spherical trigonometry, and at one time the subject was approached near enough to admit the definition of a "great" and "small" circle. The paragraphs on Vectors might have been pretermitted and given space to a more natural extension of the trigonometrical scheme. There is no such inherent difficulty in grasping the principles of solving a spherical triangle as to warrant the banishment of the subject to a comparatively late period in the pupil's educational career.

The second volume, compiled by the same author, contains logarithms of numbers to five figures, anti-logarithms, trigonometrical ratios to the tenth of a degree—a very useful subdivision—square roots and reciprocals of numbers, &c. Sundry formulæ useful in mensuration, algebra, trigonometry, the calculus, &c., are also added. Many of these tables are included in the first-named book, to assist in working the numerous examples.

BOOKS RECEIVED.

Metallurgy of Lead. By H. O. HOFMAN, E.M., Met.E., Ph.D. London: Hill Publishing Company, Limited. [Price 30*s.* net.]

Il Chimico Siderurgico Analisi dell' Acciaio e dei Prodotti Siderurgici. Professor RODOLFO NAMIAS. Milan: Ulrico Hoepli. [Price 5·50 lire.]

Handbook of Mechanical and Electrical Cost Data. By HALBERT P. GILLETTE and RICHARD T. DANA. London: Hill Book Company, Limited. [Price 30*s.* net.]

Metallurgia Generale e Siderurgia: Capisaldie Riassunti. Milan: Ulrico Hoepli. [Price 28 lire.]

Petrol and Petroleum Spirits: A Description of their Sources, Preparation, Examination and Uses. By WILFRED E. GUTTENTAG, Captain R.A.F. With a Preface by Professor Sir JOHN CADMAN, K.C.M.G., D.Sc. London: Edward Arnold. [Price 10*s.* 6*d.* net.]

Brassfounding. A Practical Treatise. By JOSEPH G. HORNER, A.M.I.Mech.E. Manchester and London: Emmott and Co., Limited. [Price 5*s.* net.]

Employers and Workmen, under the Munitions of War Acts, 1915–17. By THOMAS ALEXANDER FYFE. London and Edinburgh: William Hodge and Co. Price 20*s.* net.]

Physical Society of London. Report on the Relativity Theory of Gravitation. By A. S. EDDINGTON, M.A., M.Sc., F.R.S. London: Fleetway Press, Ltd.

United States Department of Labour. Bulletin of the Bureau of Labour Statistics, No. 231. *Mortality from Respiratory Disease in Dusty Trades (Inorganic Dusts).* By FREDERICK L. HOFFMAN. Washington: Government Printing Office. [Price 30 cents.]

Report on the Progress and Condition of the United States National Museum for the Year Ending June 30, 1917. Washington: Government Printing Office.

Simple Interest Tables (£ s. d.). By WILLIAM SCHOOLING. C.B.E., F.R.A.S. London: Sir Isaac Pitman and Sons, Limited. [Price 21*s.* net.]

The Motor Manual. Compiled and Illustrated by the Staff of *The Motor*. Twenty-second edition. London: Temple Press, Limited. [Price 2*s.* 6*d.* net.]

La Formation des Ingenieurs a l'Étranger et en France. Par MAX LECLERC. Paris: Arman Colin. [Price 2 francs.]

THE COAL SHORTAGE.—The monthly return issued by the Coal Controller shows that during the first 44 weeks of the year there was a further serious falling-off in the estimated output of coal compared with the corresponding period of last year. The net shortage is 17,679,600 tons, or about 8·3 per cent. For the four weeks ended November 9 it is estimated that 17,762,800 tons of coal were raised at mines in the United Kingdom, as against 18,951,000 tons during the corresponding period of 1917—a shortage of 1,188,200 tons. Since the end of last March the stocks of coal held at mines and in trucks have been reduced to the extent of over 1½ million tons approximately.

THE RETIREMENT OF SIR JOHN A. F. ASPINALL.

IT is announced that Sir John A. F. Aspinall, the President of the Institution of Civil Engineers, is joining the Board of the Lancashire and Yorkshire Railway Company upon his resignation of the office of general manager of that line. It is now thirty-two years since Mr. Aspinall, as he then was, entered the service of the Lancashire and Yorkshire Railway as chief mechanical engineer, and nearly twenty years since he vacated that office to become general manager. He was the first engineer who ever relinquished his technical duties to take complete charge of the affairs of an English railway, and no line in the kingdom has been better managed than that over which he has had control so long. The Lancashire and Yorkshire Railway presented a most difficult problem in the eighties. It was a complex of small lines in a densely populated district in which trade was growing daily. Many of the roads had been laid down with heavy inclines and sharp curves in a makeshift fashion, and the rolling-stock comprised numerous examples only fit for a museum. Mr. Aspinall's first job was to design and build the Horwich Locomotive Works, and then to replace the very miscellaneous assortment of engines on the line with a few new types designed to meet the extremely onerous conditions of the system, and to reduce the heavy expenses of haulage and repair which he found. Some years later the carriage and wagon departments were put under his charge and soon began to show the effects of his organising mind. Trains carried much heavier loads and the third-class passenger travelled in much greater comfort.

Early in 1899 the directors had to appoint a successor to Mr. Stafford as general manager, and they selected Mr. Aspinall. At that time such an appointment was quite an innovation, as no engineer had previously been put on the traffic side of a railway in this country. The experiment proved so completely successful that later the Great Western Railway Company and the Caledonian Railway Company each advanced one of their engineers to the chief post. The legend that an engineer is always too technical to take charge of a vast business requiring long views and broad treatment has thus been dissipated for ever, while it has been shown that an intimate acquaintance with the technical aspects of a railway gives a general manager a firmer grasp of his subject.

The Lancashire and Yorkshire Railway was in need of a manager of broad insight and great courage. Its restricted area was cut up by several of the big companies, such as the Midland and North-Western, and it had no long runs except that from Liverpool to the Humber. It stood in great need of new sources of traffic, and Mr. Aspinall set himself to find these. He devised extensions into the South Yorkshire coalfields, and made agreements with other companies for through running. It was in the extension of oversea trade that he made the greatest advances. His company has a large fleet of steamers running to Ireland and to many ports in Scandinavia, Holland, Belgium and Northern France. This class of trade involved terminal ports capable of dealing with all classes of traffic in a cheap and expeditious manner, and those equipped by Mr. Aspinall reflect his capacity both as an engineer and as a business man.

The electrification of the line between Liverpool and Southport was a great event in the railway world, and it demonstrated both the ability and the courage of its originator. The whole stretch of some 18 miles is really a suburb of Liverpool, and its traffic had grown until the capacity of the Exchange station was exhausted. This station is in the heart of Liverpool, above the general level of the streets, and its enlargement would have been a most costly affair. Mr. Aspinall decided to electrify the line, and so reduce the delays at the terminal station, while speeding up the general traffic. The designs were got out by his staff under his own supervision, and without calling in outside aid. The result was highly successful, both technically and commercially. The landowners adjacent to the line have found their ranges of sandhills gradually turned into building sites of much value.

Of Mr. Aspinall's work during the war, for which he received the honour of knighthood, it is too early to speak, but when the account comes to be written it will be seen that he played a great part in organising the railway service, which is one of the brightest and most successful features of our great effort. The movement of our standing army to the coast in 1914, with all its field equipment, ran without a hitch, and a like efficiency ever since has characterised our railway service in its military aspect. The future historian will never have to write that we muddled through in this respect, nor will he be able to draw invidious comparisons between our achievements and those of the German State Railways.

When Mr. Aspinall became a business man he did not cease to be an engineer. He has been president of the Institution of Mechanical Engineers and is now president of the Institution of Civil Engineers, and has never ceased to regard his line as a great machine. While resigning his purely technical functions to his very able successor, he has kept in the forefront of his policy the view that mechanical efficiency is the key to success, and that it is a waste of effort to do by muscular force what can be accomplished by steam or electricity. The presidential address he delivered a few weeks ago is evidence that his mind is constantly directed to cheapening the cost of transport and so facilitating the task of the British manufacturer in meeting the competition of the world. Few men have done more to raise the public estimate of engineers as men of light and leading than has Sir John Aspinall.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has sent us a copy of a new series (No. 70), of additions to the Statutory List of firms of enemy nationality or enemy association with whom persons in the United Kingdom are forbidden to trade. Copies of this can be obtained at a trifling cost from the Superintendent of Publications, H.M. Stationery Office, Imperial House, Kingsway, W.C.

THE LATE GENERAL LEANDRO CUBILLO.—We regret to read in the *Revista Minera, Metalurgica y de Ingenieria*, the announcement of the death, on the 15th inst., of General Leandro Cubillo, of the Spanish Artillery. General Cubillo was for many years the manager of the Trubia Arsenal, which he increased in power of production, and re-established on modern lines. He was appointed, later, to a post in the War Ministry at Madrid. General Cubillo has published many books, and has delivered many lectures on metallurgy and the construction of ordnance. He was an Associate, since 1890, of the Institution of Civil Engineers, and a Member, since 1885, of the Iron and Steel Institute. He has read several papers before the latter Institute.

GERMANY AND BELGIAN FIRECLAYS.—In its issue of July 18 last the German *Tonindustrie Zeitung* expatiated on the necessity of annexing all the Belgian areas containing good deposits of fireclay. It was, the journal in question states, necessary for Germany to free itself of sentimentalities and to take its good where it found it. There was a steadily increasing demand in Germany for refractories which were necessary for the ceramic, the metallurgic, and the chemical industries, and it was necessary, therefore, to ensure the supply. This need was particularly pressing in the case of Western Germany where a dearth of refractories would throw thousands of men out of work. This danger, the *Tonindustrie Zeitung* continued, could be avoided by annexing to Germany part of the provinces of Namur and Hainaut, where there are some famous beds of fireclay. This annexation was the more necessary because before the war Belgium had been a serious trade competitor with Germany, and by undercutting prices had rendered certain branches of commerce unprofitable to the Fatherland. It was necessary, therefore, that the Belgian industry should be permanently controlled by Germany. This end could not be effected with certainty by treaty, as means of evasion would be found, and a new war would be necessary to enforce it. Hence annexation was alone to be depended upon.

PERSONAL.—Mr. C. H. Wordingham, C.B.E., who, since 1903, has been head of the Electrical Department of the Admiralty and, as such, responsible for the design and supervision of the construction and completion for service of the electrical equipment of all H.M. ships, as well as for advising on all important questions of electric lighting and power connection with dockyards and other naval shore establishments, has resigned his appointment as Director of Electrical Engineering in order to return to consulting practice. His address after January 1 next will be 7, Victoria-street, Westminster, S.W. 1. Mr. Wordingham has been retained by the Admiralty to continue acting in an advisory capacity.—Mr. Clifford C. Paterson desires to announce that he is terminating his appointment at the National Physical Laboratory, Teddington, and is joining the General Electric Company, Limited, as director of research laboratories, as from January 1, 1919. Pending the erection of the necessary laboratory buildings, the temporary offices and address of the Research Laboratories of the General Electric Company, Limited, will be at the Osram Robertson Lamp Works, Hammersmith, London.—In view of the recent rapid progress of events affecting British engineering industry and the export trade, the Council of the British Engineers' Association, in order to cope with the vast amount of important work which will devolve upon them in the immediate future, have decided to strengthen their administration by the appointment of a director, who will be the chief organising and executive officer of the association. To fill this responsible position the council have secured the services of Mr. D. A. Bremner, O.B.E., who, as an engineer, business organiser and administrator, has had a wide experience at home and abroad. Mr. Bremner will assume his position in January 1, next.—The Stanton Iron works Company, Limited, near Nottingham, have entered into a working arrangement with Messrs. James Oakes and Co., Alfreton Ironworks, Derbyshire, under which the Stanton Company will, from January 1 next, act as sole selling agents for the products of Messrs. James Oakes and Co.'s blast furnaces and foundries. Messrs. James Oakes and Co.'s foundries have been devoted largely to the manufacture of flange pipes, special castings of every description, for chemical and coke-oven plants and for circulating, cooling, boiler and electric power plants.

REINFORCED-CONCRETE SHIPS.

To the Editor of Engineering.

Sir,—The interesting extract from *The London Journal*, of December 23, 1854, accompanying the letter from Mr. H. R. Cullen, in your issue of December 6, embodies a somewhat amusing error. The novelty in shipbuilding recorded was not the work of "M. Lombo-Miraval," but of M. Lambot, who lived in the French town of Miravel. Built in 1849, the craft in question has been used as a pleasure boat on a lake in a private park, where it is still to be seen in the present day, as sound as ever, after nearly seventy years' service under the most severe conditions to which reinforced concrete structures can be submitted. Although shown at a Paris exposition, and carefully examined by the French Admiralty in 1850, the Lambot boat seems to have attracted very little attention otherwise, and the patentee was unable to persuade the Government to adopt his new method of shipbuilding. Forty or fifty years later, a great impetus to the building of concrete vessels was given by the enterprise of private firms in France, Italy and other Continental countries, and as a result of their pioneer work the application of reinforced concrete to shipbuilding was at last taken up on an extensive scale by the French, Italian, British, American and other Governments.

I am, Sir, your obedient Servant,

W. Noble Twelvetrees.

London, S.W., December 13, 1918.

THE QUEBEC BRIDGE.

To the Editor of Engineering.

Sir,—Your issue of September 13 is to hand with its very interesting and accurate description of the Quebec Bridge. The opening paragraphs, however, give a wrong impression as to the responsibilities and work of the engineers representing the Government, the contractors and as to the design of the superstructure. I am confident you will welcome correct information for use in the event you again have occasion to refer to the subject, and I am therefore sending you the text of an illustrated lecture given before the Canadian Society of Civil Engineers last January, in which I have marked certain paragraphs referring to this part of the work on pages 2, 3, 4, 11, 12, 16 and 49. The information may be condensed chronologically as follows :—

August 29, 1907.—Bridge under construction by Phœnix Bridge Company failed.

August 31, 1907.—Government appointed a Royal Commission to investigate the accident.

August 17, 1908.—Government appointed a Board of Engineers, as under, to "prepare plans and construct the bridge on these plans" : Mr. (now Sir) Maurice Fitzmaurice, C.M.G., M.Inst.C.E. ; Mr. Ralph Modjeski, A.M.Soc.C.E. ; Mr. H. E. Vautelet, M.Can.Soc.C.E., chairman and chief engineer.

June 1, 1910.—Mr. Fitzmaurice resigned.

June 17, 1910.—Advertisement inviting tenders on Mr. Vautelet's official design and on contractor's alternative designs.

September 28, 1910.—Mr. Charles MacDonald, past-president Am.Soc.C.E., appointed to succeed Mr. Fitz-Maurice.

October 1, 1910.—Tenders received by Government and opened.

January 20, 1911.—Government appointed Mr. M. J. Butler, C.M.G., Past President Can.Soc.C.E., and Mr. H. W. Hodge, Am.Soc.C.E., to assist Board in selecting a design.

February 8, 1911.—Messrs. Modjeski, MacDonald, Butler and Hodge reported in favour of St. Lawrence Bridge Company's design, Mr. Vautelet dissenting.

February 28, 1911.—Mr. Vautelet resigned from the Board. The remaining members of the Board then changed the span from 1,758 ft. to 1,800 ft, modified the specifications and, in conjunction with the contractors, modified the design, but retained all the essential features of the design submitted with the tender.

April 4, 1911.—The contract was signed, the design for the bridge was signed as part of the contract, as were also the specifications. When the contract was signed Mr. MacDonald desired to be relieved of further detail work and Messrs. Butler and Hodge ceased to be members of the Board by the terms of their appointment, thus leaving Mr. Modjeski the sole remaining member of the Board that had decided on the plans and specifications.

May 6, 1911.—Mr. C. N. Monsarrat, M.Can.Soc.C.E., was appointed to the position made vacant by Mr. Vautelet's resignation.

May 15, 1911.—Mr. C. C. Schneider, Past President Am.Soc.C.E., was appointed to complete the Board of three.

January 8, 1916.—Mr. Schneider died. Mr. H. P. Borden was appointed to fill the vacancy created by the death of Mr. Schneider.

After the contract was signed, on April 4, 1911, no change could be made in the design or specifications without the mutual consent of the contractors and the Board of Engineers.

The contractors were obliged to submit with their tenders complete designs showing stresses, material, details and methods of erection proposed. All the working drawings were prepared by the contractors and the erection was carried out at their sole responsibility. A prominent condition of the contract specification read in part as follows :—

"The contractor will be required to guarantee the satisfactory erection and completion of the bridge, and it is to be expressly understood that he undertakes the entire responsibility not only for the materials and construction of the bridge, but also for the design, calculations, plans and specifications, and for the sufficiency of the bridge for the loads therein specified. And the enforcement of any part, or all parts, of the specifications shall not in any way relieve the contractor from such responsibility."

It will be seen from the foregoing that the functions of the Board of Engineers, after its completion by the appointment of Messrs. Monsarrat and Schneider, were supervisory and almost wholly executive, the engineering features having been fully determined before their appointments were made. It should be noted, however, that the experience and counsel of Messrs. Modjeski and Schneider was of much value in connection with certain changes later agreed to by the Board and the contractors. When Mr. Borden was appointed all the working drawings were complete, and the work itself was practically manufactured and erected with the exception of the suspended span.

Yours truly,

Phelps Johnson, President.

The St. Lawrence Bridge Company, Limited, Montreal, Canada, October 18, 1918.

"STUDENTS FOR DEGREE COURSES."

To the Editor of Engineering.

Sir,—The thanks of students for Natural Science Degrees are due to you and to Messrs. Butterworth, Ackerman and Guest, for further ventilation of this subject originating in my letter which appeared in your issue of November 29. I write again solely to express agreement with Mr. Guest upon the point that such degrees must not be made "cheap" in sympathy for those who have lost time due to military service. Such a course would be unjust alike to them and to those already holding degrees. As I stated in my original letter, taking (for example) the B.Sc. Degree on evening study would be for most a trying process. There are, however, some men of conspicuous ability who could and would go through if they had the chance. I submit it is a national duty to give them this chance.

Yours obediently,

F. Roland Wollaston.

Lord's Chambers, 26, Corporation-street, Manchester, December 16, 1918.

THE POSITION OF THE OFFICIAL IN ENGINEERING AND OTHER WORKS.

To the Editor of Engineering.

Sir,—Much attention has been given to the relations between the capitalist employer and Labour, and this is most ably dealt with in the article on the Labour Issue by Mr. Alexander Ramsay in Engineering of November 29, 1918. Up to the present, however, little regard has been given to the official who comes between the two. I consider that even junior clerks and draughtsmen really constitute part of the labour required to keep an engineering works going ; and by the word "official" I mean the heads of departments, together with their subordinates, such as the head clerks in the counting house and in the secretarial, estimating and other departments, the head draughtsman in the drawing office, the works manager with his under-managers and foremen, and generally all who are paid an upstanding wage or salary.

During the war, this class has received only small increases of salary, and in some cases none ; sometimes bonuses have been given, but these it is expected will be discontinued after the war. Officials have been most loyal in working under the greatest difficulties and with excessive overtime during the war ; and it seems to me to be much to the discredit of employers that more has not been done for them. In many cases they have been working for salaries very much below the wages paid to the workmen under their control ; and it must be remembered that they are expected to keep up a certain position, so that they have been hit very hard. The official class has *no trade union*, and therefore has been entirely at the mercy of the employer. It has been found practically impossible to get educated men to combine ; but there are now some signs of combination in the Association of Draughtsmen, and in the various foremen's associations, and these signs I am glad to see.

It is not only the question of salary that arises, but the general treatment of the official. The first experience a man generally has when he is made upstanding, and is given an official position, is, that he is expected to work overtime without extra pay almost regularly. The employer takes the utmost care not to work men overtime who are paid extra for it ; but he exacts overtime from the man who receives the upstanding wage, because he has not to pay for it. In this direction the average employer is often most thoughtless. A common habit of heads of firms is to come in late and stay late, and to make a rule that officials must not leave before they do ; but they take good care to see that the officials turn up at the proper time in the morning. No good official objects to working overtime when it is necessary ; but such a way of getting overtime out of him is most irritating and unjust. I have known cases of an employer spending the week shooting, coming in on Saturday morning at about 11 o'clock, and keeping the officials the whole afternoon.

It is true that in most works an official gets a fortnight's holiday, with pay ; but on the other hand he is expected to be about the works in general holiday times, in case anything turns up, and to look after repairs. On the whole, therefore, he gets a much shorter holiday per annum than the average workman.

Another point that needs to be dealt with is the very unfair agreements that employers often ask their officials to enter into. In one case, the officials of a firm were asked to sign an agreement providing that all information obtained by them, by experiment or otherwise, during the time they were with the firm was to be for the benefit and at the service of the firm, and was to be considered private and not made use of or divulged without the firm's consent. It will be seen from this that if a man left (and it must be remembered that the firm reserved the full right to discharge a man at any time) he could not make use of any information of whatever kind that he had obtained while with the firm ; and a young man would, of course, obtain general engineering knowledge, which, by the agreement, he could not make use of. Such a restraint is contrary to law ; but to a large extent a case in the law courts goes in favour of those that have most money ; few officials would be able to afford to fight their firms, and still less to incur the risk of heavy costs if the verdict went against them.

The whole question of patents, again, requires attention. A common agreement provides that all inventions by the official shall be patented in the name of the firm and for its sole benefit ; and in some cases attempts have been made to prevent a man's patenting his own inventions even after he has left the firm.

It seems to be almost forgotten that the official is as essential for the carrying on of industry as the employer and the workman ; and unless fairer treatment is given him, there will be little encouragement for a man to undergo the expensive training and education that are necessary in order to qualify him to become an official, when officials are not only subjected to bad treatment at the caprice of the employer, but often receive lower pay than the workmen who are under them.

Yours truly,

December 11, 1918. "An Ex-Official."

WOOLWICH ARSENAL.

To the Editor of Engineering.

Sir,—My attention has been directed to your leading article on page 587 of your issue of November 22, which contains a reference to Woolwich.

A shell-maker is quoted as saying that the chances of winning the war would have been substantially increased if Woolwich and all its works had been destroyed by Zeppelins. In my opinion, and my views are based on actual experience of the Arsenal throughout the entire period of the war, this statement is grossly unfair to Woolwich as a whole ; I had no opportunity of seeing the shell plant in the early days. When the call came to the engineering community to organise themselves in the production of munitions, it was to Woolwich that the great majority went.

With regard to manufacture, although engineers were not always struck with the simplicity of the design of the articles they were called upon to make, from the production point of view they were largely of the opinion that the work carried out at Woolwich was in every way creditable, and moreover the unselfish manner in which all the managers at the Arsenal afforded assistance and information is a pleasant recollection of these strenuous days.

I am sure that the usual sense of fairness which characterises your informative and excellent journal will induce you to correct the unhappy impression given by the statement in your article referred to.

I am, yours faithfully,

"D."

December 16, 1918.

[We most willingly insert our correspondent's letter as we know that he is not only well acquainted with the present conditions at Woolwich, but also, as the head of one of the most important engineering establishments which promptly took up war work in the early days, had personal experience of the matters about which he writes. At the same time it is certain that the expression of opinion quoted in our article was by no means an isolated one. The difference in the points of view is probably explicable by the fact that Woolwich Arsenal is a vast establishment made up of a number of departments varying considerably in efficiency, and that the conclusions arrived at by each critic have been based on his experience in connection with the particular department with which he was brought into contact.—Ed.E.]

DIVISIONAL ENGINEERS ; ROYAL NAVAL DIVISION.

To the Editor of Engineering.

Sir,—As you are no doubt aware, in 1914 the Institutions of Civil, Electrical and Mechanical Engineers assisted in the formation of a unit known as the Divisional Engineers, which was attached to the Royal Naval Division. As many of these men are now discharged, or are being demobilised under the present scheme, I shall be greatly obliged if you will kindly insert a short paragraph in your paper asking any member of the original No. 3 Section of the 1st Field Company to communicate with me, care of Messrs. Nuttall and Co., Limited, Ravenhead, St. Helens, Lancashire.

My reason for this is that several of us are very anxious to get in touch with as many of the original men as possible, with a view to making arrangements for a reunion.

I am, yours very truly,

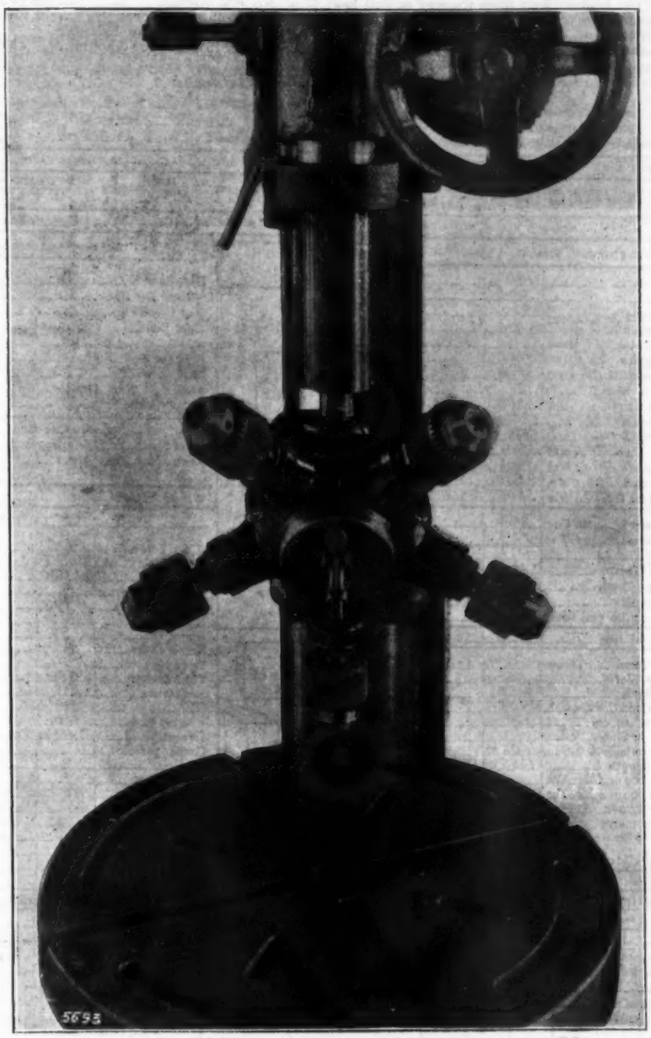
C. Saxton.

December 16, 1918.

Cast-Iron Piston Rings by the Lavaud Centrifugal Machine : Erratum.—We regret that a peculiar misprint in the heading of a Note published on page 687 *ante* was overlooked in last week's issue, carbon being printed instead of cast-iron. The title of the Note should read : Cast-Iron Piston Rings by the Lavaud Centrifugal Machine.

THE FORTIN 5-SPINDLE TURRET DRILL HEAD.

CONSTRUCTED BY THE SPAFFORD TOOL WORKS, HARTFORD, CONN.



WE illustrate on this page a turret head for a drilling machine. The device is due to the Spafford Tool Works, of 10, Hoadley-place, Hartford, Connecticut, U.S.A., and has met with a considerable demand, since where different sizes of drills are required at one setting of the work, or different operations have to be effected, it takes much less time to rotate the turret than to change a tool. As shown in our illustration, the turret has five heads, and the arrangement is such that only the operative head is driven, and whilst this is at work the other heads remain stationary. The driving arbor fits on to the drill spindle, and the turret is kept from rotating, as a whole, by an adjustable rod which couples it to a clamp fixed to the sliding sleeve of the drilling machine. This rod also prevents the turret from falling should the arbor jar loose. On pressing the lever visible in front the turret can be rotated either way, allowing the head required to be brought into the working position. This can be done without stopping the drill spindle.

THE AUSTRIAN LLOYD.—This large concern, which before the war had a fleet of 65 boats with an aggregate tonnage of 220,000 tons, is now compelled to liquidate, and other Austrian shipping companies will probably have to do the same. The Austrian Lloyd showed a deficit for last year of 1,909,435 Austrian kronen, of which 39,000 kronen were covered by the reserve fund, the balance, together with the losses from 1915 and 1916, making up an aggregate of more than 4,500,000 kronen, being carried forward to the current year. The company is domiciled in Trieste, and its trade was principally with Mediterranean ports. A good many of its boats were seized in foreign waters, and others have been lost in war service.

THE SUPPLY OF SINGLE-PHASE POWER FROM THREE-PHASE SYSTEMS.*

By Professor MILES WALKER, D.Sc.

(*Continued from page* 695.)

(5) A ROTATING BALANCING TRANSFORMER.

This absorbs the balanced three-phase power in one winding and supplies a single-phase load from an independent winding.

A balancer of this kind is of special interest in connection with single-phase electric furnaces.

The main advantages claimed for the single-phase furnace are as follow:—In the first place, only two electrodes are required instead of three; and as these can be brought into the furnace at two diametrically opposite points the liability of the arc to cause a short-circuit through the hot semi-conducting lining is very much reduced. This enables the voltage between the terminals to be raised to a value almost double that which is practicable for a polyphase furnace. The increase in the voltage leads to a corresponding reduction in current for the same power input; the smaller current leads to economy in conducting cables and contacts and enables a much smaller electrode to be used than is possible in the polyphase furnace. As the electrode losses are dependent upon the surface of carbon exposed and also upon the amount of air-leakage through the furnace, the reduction in the number and size of the electrodes and in the number and size of leakage holes results in a great saving in electrode consumption. In the second place, the single-phase furnace has an exterior shape which approaches a spherical form; the radiation losses are thus reduced to the smallest possible for a given content.

* Paper read before the Institution of Electrical Engineers on December 5.

Requirements in balancer for single-phase furnace work.—When the purpose is to supply a single-phase current to an electric furnace, the source of supply being an ordinary three-phase system, there is an advantage in using a special kind of balancer which shall fulfil the functions of (1) voltage transformer, (2) balancer, (3) reactance, and (4) power-factor corrector. These functions can of course be performed by a motor-generator set designed with suitable characteristics; but the first cost of a motor-generator set is higher than that of a balancer of the same output, and the efficiency is lower. More clearly to understand the functions of such a balancer, something should be said of the advantages (from the user's point of view) of working a single-phase furnace with an inductance in circuit sufficient to make the current lag by 45 deg. behind the voltage.

Consider the circuit shown in Fig. 20, where O P is the primary winding of a transformer, O T its secondary winding, T X a choking coil, and F a single-phase furnace. In the vector diagram, Fig. 22, let O T represent the voltage generated by the secondary, X T the reactive drop in the choke coil (with which may be included any reactive drop in the transformer). Let F X represent the reactive drop in the furnace, and O F the resistance drop in the furnace and the rest of the circuit. If this diagram represents the full-load working conditions, then the full-load current is lagging 45 deg. behind the voltage, and is represented to some scale by the line O F. When the inductance and resistance are adjusted to give these conditions on full load, and the inductance is maintained constant, the voltage O T being constant, the input to the furnace cannot exceed* the full-load value however the resistance of the circuit may be varied. In fact, if we change the resistance of the furnace from infinity to zero, the current will increase from 0 to 1·41

Fig. 20.

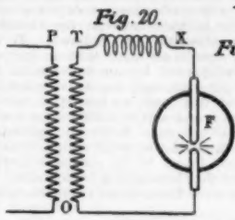


Fig. 21.

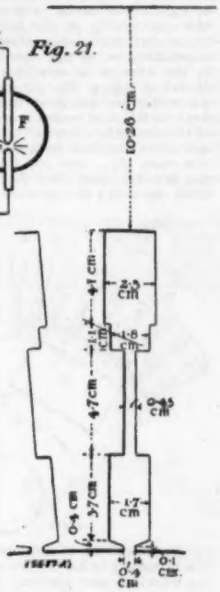


Fig. 22.

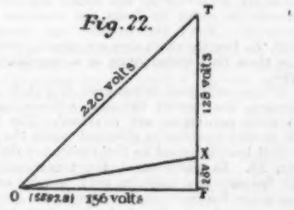
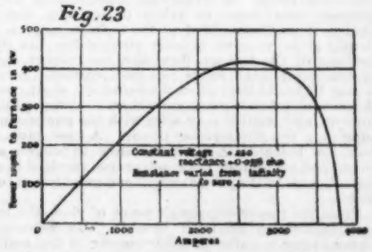


Fig. 23



* The proof of this is as follows:—

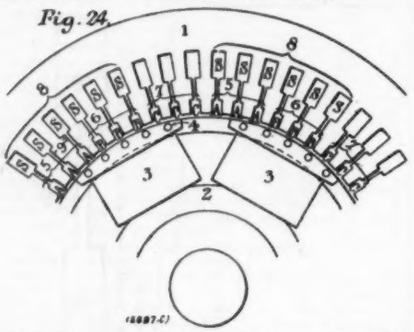
$$\text{Power} = E\,I\cos\phi = E\frac{E}{\sqrt{(R^2+X^2)}}\frac{R}{\sqrt{(R^2+X^2)}} = \frac{E^2R}{R^2+X^2}.$$

This is at a maximum when R = X.

times full-load current, and the power at various values of the current will be given by the curve in Fig. 23. The full-load value of the current gives the highest point of the curve. Any reduction of the resistance of the furnace beyond this point causes a decrease in the input, although the current is slightly increased. If the furnace is short-circuited, the input falls to zero and the current cannot exceed 1·41 times full-load current.

The importance of stability.—These conditions give stability in operation, and are of great importance in preserving the lining of the furnace. No really satisfactory refractory substances can be obtained for the lining of electric furnaces. The best commercial substances, such as dolomite, magnesite, or silica brick, have melting-points not very far above the temperature at which it is desired to work the furnace. If by any unfortunate chance part of the lining reaches a temperature above its melting-point, it begins to blend with the contents of the furnace, causing trouble with the pouring and heavy expense in re-lining. Now the maintaining of the furnace at its proper temperature depends upon the maintaining of the balance between the electrical input and the energy absorbed and radiated. If the characteristics of the circuit are such that an increase in the current is accompanied by an increase in the electrical input, the greatest care must be exercised when the furnace is at full load, to keep the current near its full-load value; and this is difficult by reason of the unstable nature of the arc. Automatic regulators are often installed to keep the current within bounds, but even these are not found to be sufficient during the first 20 mins. after the furnace has been started up from the cold; and in some three-phase furnaces, where

Fig. 24.



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no great amount of inductance is connected in circuit, it is necessary to have three operators (one at the regulating wheel of each carbon), with their eyes fixed on the ammeter, to screw up and down the carbons every few seconds in order to keep the currents approximately balanced. After the furnace has been heated fairly well, the length of its arcs are greater, and the regulating can then be handed over to a regulator of the Thury type.

Where sufficient inductance is put in series with the furnace, the circuit becomes automatically stable and no such regulators are required. The ideal condition for steady running is attained when the inductive drop at full load is equal to the resistance drop, as shown in Fig. 23. In some cases, the transformers that supply the furnace are built in such a way as to have their magnetic leakage great enough to give the required inductive drop. In designing transformers for this purpose, care must be taken to see that the cross-section of any iron added to the leakage paths is sufficiently great to give a fairly straight-line law for the increase of the leakage flux with the current, right up to the point 1·41 times full-load current; otherwise it may be found that when the furnace is short-circuited the current taken is much more than 1·41 times full-load current, and trouble may arise with the power company supplying the three-phase power. A case came to the notice of the author in which failure to provide a sufficient cross-section for the reactive iron resulted in undue disturbances to the power system and great loss of furnace linings.

From the power company's point of view, the inductance is not an unmixed blessing. By reducing the power factor it calls for more copper in the mains for a given load, and reduces the output of the generators. Sudden heavy calls for low power-factor current have a bad effect upon the regulation of the whole system. But so greatly does the stability given by the inductance help towards economy in furnace linings, that large numbers of furnaces in this country and in America are run at 0·7 power factor. The single-phase furnace, having only one carbon at the top, presents a smaller area of roof lining to the fierce radiation from the arc, and for this and other reasons set out above it is more economical than the three-phase furnace.

Design of Balancer for Single-Phase Furnace Work.—It will be seen, then, that in designing a balancer to provide a single-phase furnace load from three-phase power mains it is desirable that the single-phase winding should have such a high inductance that the current will lag 45 deg. at full load. At the same time, it is desirable that the three-phase winding should be operated at unity power factor. These conditions can be met by building a three-phase synchronous motor having an ordinary three-phase armature winding lying in slots near the working face of the stator (see Fig. 24), and provided with a single-phase winding lying in slots further removed from the rotor than the three-phase slots and arranged so that very considerable magnetic leakage occurs between the two windings at full load.

The dimensions of the three-phase slots near the surface of the armature and of the single-phase slot lying in the centre of the punching are shown in Fig. 21. This figure also shows a narrow slot 0·45 cm. wide, across which the leakage flux finds its way at full load. The calculations here given show how one can arrive at the characteristics of such a machine. The machine described is one of two designed for the Snyder Electric

Effective inductive drop in furnace and cables	... 25 volts to 50 volts.
Single-phase voltage at terminals of balancer	... 160.
Inductive drop in windings of balancer	... 110 to 130.
No-load voltage	... 220 to 247, say 234.
Single-phase amperes	... 2,400 to 2,700.
Temperature rise of balancer after full load for 3 hours	... 45 deg. C.

3-phase to Single-phase Balancer

Date 4 Jan ...19/6. Type ~~GEN. ETH MOTOR ROTARY~~ 8 Poles ... Elec. Spec ...

K.V.A. 444 ... P.F. 0·9 Phase 3 Volts 6000 to 220 ... Amps per ter 2750 ... Cycles 50 ...; R.P.M. 750 ...; Rotor Amps ... ;

H.P. ... Amps p. cond 97 ... Amps p. br. arm. ... Temp. rise 45C ... Regulation ... Overload 90% for 10 secs

Customer Snyder Elec Furnace; Order No 338/16 ...; Quot. No. ...; Perf. Spec. ...; Fly-wheel effect ...

Frame 140/42 Circum 288 , Gap Area 12,100 ... poss. A_2 B ...; poss. $l_2 Z_2$ ...; $l_2 Z_2$ = 198 $\frac{D^2 L \times RPM}{K.V.A.} = 6 \times 10^5$

Air ... A_2 B 1·03 x 10 ...; $l_2 Z_2$ 54,200 ...; Circum ...;

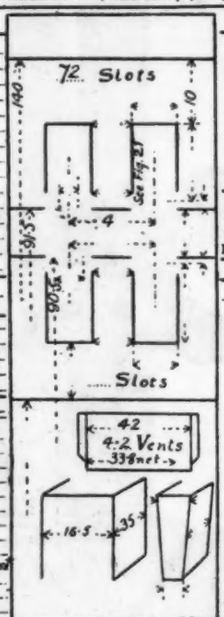
K_e ... 5940 ... Volts = 0·9 × 12·5 × 1152 × 1·03 ... ; Arm. A.T. p. pole ... ; Max. Fld A.T. ...

Armature.	Rev.	Stat.
Dia Outs	140	
Dia Ins	91·5	
Gross Length	42	
Air Vents 6×0·7	4·2	
Opening Min ... Mean ...		
Air Velocity 36 m. per Sec		
Net Length 37·8 x Bq	33·8	
Depth b Slots	10	
Section 340 Vol	140,000	
Flux Density 9800 n l	8800 f l	
Loss ·04 p cu cm. Total	6500 + 4000	
Burned Cu 2870 Total	11500	18,370
Gap Area 12,100 : Wts	5900	
Vent Area 3,000 : Wts	8200	
Outs Area 5870 : Wts	5800	19900

Core.	
Weight of Iron	2100

Teeth.		
No of Segs ... Mn Circ	294	
No of Slots 72 ... x 1·7 =	123	
K	1·71	
Section Teeth	5800	
Volume Teeth	23000	
Flux Density	17,800	
Loss ... p. cu cm Total	5000	

Conductors.		
Star or Mesh ... Throw	1-12 2-11	3-10
Cond: p. Slot	16	
Total Conds	1152	
Size of Cond 0·26 × 0·5	0·127	
Amp. p. sq. cm	370	
Length in Slots 42		
Length outside 66 Sum	1·08 m.	
Total Length	1255 +	159
Wt of 1,000 m 113 Tot		
Res. p. 1,000 m 1·34 Tot	1·9	2·22 hot
Single-phase ·0044 +	8· ·00055	
Watts p. metre	53	
Surface p metre	1040	
Watts p. Sq. cm ·05/·0·5 = ·0012	·056	
	13°C	



Field ~~Core~~ Rotor

Dia. Bore	90·5
½ Total Air Gap	0·5
Gap Co-eff K,	1·08
Pole Pitch ... Pole Arc	
K_i ... no load ...	full load
Flux per Pole 8·6 × 10⁶	6 × 10⁶
Leakage n l ... l l·3	9·9 × 10⁶
Area 570 Flux density	17400
Unbalanced Pull	

No of Segs	Mn Circ	
No of Slots	x	=
Vents		
K_i ... Section		

Weight of Iron ...

	Shunt.	Series.	Comm.
A.T. p Pole a. Load	5920		
A.T. p Pole f. Load	8500		
Surface	32,000		
Surface p Watt	7		
I² R.	4900		
I. R.	129		
Amps.	38		
No. of Turns	224		
Mean l Turn	110		
Total Length	2080		
Resistance	2·9 cold		
	3·4 hot		
Res. per 1,000	1·36		
Size of Cond	0·14 sq cm		
Conds per Slot			
Total			
Length			
Wt. per 1,000	116 kilo		
Total Wt	232		
Watts per Sq	0·143		
Star or Mesh			
Paths in parallel	1		

Magnetization Curve.

	Section	Length	5500 Volts. B.	A.T. p cm.	A.T.	5940 Volts. B.	A.T. p cm.	A.T.	6200 Volts. B.	A.T. p cm.	A.T.
Core	340	50	8150	2	100	8900	3	150	9200	3·5	175
Stat. Tth	5800	7	16,500	50	350	17,800	100	700	18,600	130	910
Rot. Tth	6500	1·5	14,800	20	30	16,000	40	60	16,600	50	75
Gap	12,100				3370	8500		3640			3800
Pole n l											
Voke	360				90			150			200
No Load											
Pole f l	570		15,800	30	360	17,000	60	720	17,800	90	1080
					4300			5420			6230

Commutation.

Dia	L_1
Speed	L_2
Bars	L_3
Volts p. Bar	L_4
Brs. p. Arm	L_5
Size of Brs.	$p_1 + b_1 \cdot c_1$
Amp sq. cm.	B_1
Br. Loss	B_1'
Wts. sq. cm.	

EFFICIENCY.	½ load	Full.	¾	1	1¼
Friction and Windage		6		6	
Iron Loss		12·5		12·5	
Field Loss		5		4	
Arm. &c I²R		10·9		2·7	
~~Brush I²R~~ Losses on load		8		2	
		42·4		27·2	
Output		400		200	
Input		442·4		227·2	
Efficiency %		90·4		88	

Mag. Cur ... Loss Cor.
Perm. Stat. Slot ... =
.. Rot. Slot x ... =
.. Zig zag ... =
2 x ...
1·73 ... x ... =
End ... x ... =
Amps: Tot
y = ... I_2 =
S_1/S ... I_1 = +

Imp √ + =
Sh. cir. Cur.
Starting Torque
Max Torque
Max. H.P.
Slip
Power Factor

CALCULATION SHEET FOR THREE-PHASE TO SINGLE-PHASE BALANCER.

Furnace Company and now in successful operation in this country. Another, somewhat similar, machine has been designed to be built by the Allis-Chalmers Company, of America, and several machines of larger output are in contemplation. The British machines are required for furnaces to make steel for war purposes.

In the case of the 400-kw. balancer here described, the following were the particulars of the conditions to be met:—

Three-phase supply. Line voltage.	6,000 at 50 cycles.
Input to furnace	... 350 kw. to 400 kw.
Voltage on arc and connecting cables in phase with the current	... ... 156.

The inductive drop in the furnace was a quantity that could not be given exactly by the makers, and therefore allowance had to be made in the windings of the balancer so that if the inductive voltage came out high a rather higher no-load voltage could be obtained. Arrangements were made so that a no-load voltage of 247 could be obtained if it should be necessary. Before this balancer was completely wound, measurements were made on another furnace, from which it appeared that the inductive drop in furnace and leads would come out at about 28 volts, and that the best relation between the various voltages would be that indicated in Fig. 22.

The method of fixing upon the size of frame and the other dimensions in order to secure the requisite charac-

teristics is given in Appendix VII. The calculation sheet of the machine is here given (page 724).

Compensating Winding.—One of the special features of this type of balancer is a compensating winding designed to inject a boosting voltage into the two phases of the three-phase winding that lie adjacent to the single-phase winding, in order to prevent those windings from taking more than their share of the load. If this winding were not provided, phases A and C (adjacent to which the single-phase slots are placed) would take a load equivalent to a single-phase load on the three-phase system by reason of the fact that the magnetic coupling between these phases and the single-phase coils is more complete than the coupling between the single-phase winding and phase B. Another way of looking at the matter is this: When current passes through the single-phase winding, it drives magnetic flux* across the three-phase slots of phases A and C and causes an inductive drop in these phases; so that there will flow from the line a current of such value and of such phase that it produces an impedance rise sufficient to balance the inductive drop produced by the single-phase magnetomotive force. Since the resistance drop is small, compared with the reactive drop, the excess current that would be taken by phases A and C would be almost in exact opposition of phase to the single-phase current.

One way of preventing this action is to inject into phases A and C an electromotive force which shall at all times be exactly equal and opposite to the electromotive force generated in the three-phase winding by the interlinked flux from the single-phase magnetomotive force. The most direct way of doing this is to wind a few turns of wire interlinked with the main leakage path of the single-phase winding, and electrically connect these to phases A and C so that the E.M.F. generated in the turns by the main leakage shall oppose the E.M.F. generated in the three-phase winding by the small leakage across the three-phase slots. As the leakage flux across the leakage air-gap is great, compared with the leakage across the three-phase slots, only very few turns of compensating winding are required to balance the E.M.F., in the 16 conductors per slot of the three-phase winding. The counter magnetomotive force set up by these few turns is so small, compared with the magnetomotive force of the single-phase winding, that it can be neglected in roughly estimating the number of compensating turns required. In Appendix VIII is given the method of calculating the number of compensating turns required. The manner of winding and connecting the compensating conductors can be seen from Figs. 25 and 26.

Tappings on the Three-Phase Winding.—In order to provide a means of making small adjustments in the balance of the load on the three-phase winding after the machine was built, three tappings were taken off each of the phases near the star point. These were at 3, 6 and 9 turns respectively away from the inner end of each phase. As there are 102 turns per phase, the tappings give a choice of cutting out 1·56 per cent., 3·12 per cent., or 4·68 per cent. of the phase voltage. In practice it was found that the connection that gave the best result with only 3 compensating turns connected was that shown in Fig. 27. The effect of this slight dissymmetry in the connections was a slight dissymmetry at no load, as shown by the figures on page 692 *ante*. This dissymmetry is of no importance in practice, and can be eliminated in future by the better adjustment of the compensating winding. When there is no load on the single-phase winding, there is no E.M.F. in the compensating winding*; and as it is the same magnetomotive force that operates upon the compensating winding as operates upon the three-phase winding and creates a tendency to unequal back E.M.F., the right adjustment of the compensating winding should bring about a nearly exact balance of the phases. The currents in the damper on the field poles also tend to create a disturbance in the balance of the load; this disturbance is of a very complex nature, but fortunately is not of very great moment.

The Damper on the Field Poles.—The damper consists of nine drawn copper bars of taper section. These are held in dovetail slots in the pole face, and pinned and sweated to a copper casting encircling each pole. The copper castings are bolted together from pole to pole so as to form a complete squirrel-cage winding. In order to avoid any inductive action between the individual stator slots and the bars of the damper, the slots on the field poles are skewed through a complete stator slot pitch. It was found that with this arrangement the damper showed no signs of heating at no load, and only very slight heating at full load. On a previous machine in which this precaution was not taken, there was a considerable loss in the damper at no load, owing to the inductor action of the stator teeth.

General Method of Design.—Apart from the special features above mentioned, the design of the balancer follows very closely the design of an alternating-current generator or synchronous motor. The full details of the design are given in the calculation sheet on page 724. It is unnecessary here to do more than supplement the explanation given in the author's book of the general method of design.

Ampere-Turns on the Field Magnet.—These are calculated in Appendix IX.

Heating and Cooling of the Frame.—The calculation of the heat generated at full load follows the rules given in the book referred to, except that on this machine one has the copper losses of two armatures, and rather heavier eddy-current losses in end plates than on simple generators of the same size. As against this, the air-gaps provided in the leakage path around the single-phase winding afford a very effective cooling surface not found in ordinary machines. This can only be utilised well if an efficient fan is provided to blow a very positive blast of air through the ventilating ducts. The machine was accordingly built with end bells designed so as to enclose the air from the fan blades on the field magnet and to compel a great part of it to traverse the ventilating ducts, while the remainder passed over and between the armature coils before it escaped at ducts provided at the periphery of the end bells.

Armature Losses.—The various losses and the manner in which the heat is carried away are given in Appendix X.

Efficiency.—The measured friction and windage, iron and field losses are filled in their respective places on the calculation sheet. In addition to these losses, an allowance of 8 kw. has been made for extraneous loss at full load, bringing up the total losses at full load to 42·4 kw. Thus the efficiency works out at 90·4 per cent. So far as could be ascertained from measurements made on integrating meters over a number of runs on the furnace, this figure is very near the mark.

Tests.—It was not possible to make a load test at the maker's works, for sufficient power was not available. Particulars of the no-load tests are annexed.

The full-load test was made after the machine had been delivered to the works of Messrs. Summerson, Limited, Darlington. Characteristic figures of the test are annexed. It will be seen that when running light there is a dissymmetry in the power taken by different phases: this is due to the arrangement of taps shown in Fig. 27, but does not cause any measureable interference with the voltage at the end of a long feeder. When the furnace is in circuit, the amount of load can be varied slightly by altering the distance between the electrodes. The point of maximum load is in practice found by trial. Any increase or decrease of the length of the arc from this maximum load point causes a decrease in the load. It is sometimes convenient to vary the load by changing the length of the arc, but the steadiest conditions are obtained when the arc is on the maximum-load point. It will be seen that the balance of the load is quite good, the currents in the three lines A, B and C being 45 amperes, 45 amperes and 49 amperes respectively. The deviation from the perfect balance is not more than is often found on standard polyphase machines.

Short-Circuit Conditions.—A very interesting experiment is to screw down the top carbon until it dips into the metal in the furnace. As the arc is shortened, the voltage falls; when the carbon is in contact with the metal the voltage cannot be read on the voltmeter and the watts fall to a small amount of the order of 75 kw., depending upon the condition of the charge. The current rises to somewhere between 3,500 amperes and 3,800 amperes. The load on the three-phase side falls to about 121 kw. This is satisfactory from the power company's point of view.

The author wishes to express his thanks to the Snyder Electric Furnace Company for permission to publish the figures given in the paper, to Messrs. Sandycroft, Limited, for supplying data of the balancer, and to Mr. J. A. Kuyser for the values of the voltage drop in each phase of a three-phase generator, given below.

MESSRS. SANDYCROFT, LIMITED.

TEST SHEET.

Date, March 15, 1917.

For Snyder Electric Furnace Company.

No-Load Losses.

Order No. 338/16. Motor No. 1,393. K.v.a. 444. Volts 6,000/166. R.P.M. 750. Cycles 50.

Balancer.						Driving Motor.						
Speed	Volts, K = 120.	Exciting Amps.	Exciting Volts.	Resistance.	Single-phase Volts.	Volts.	Amps.	Field.	Total Watts	Armature I^2R.	Difference.	Remarks.
758	49·7 5,970	26·5	83·8	3·15	219	209	48·7	18·0	25,400	535	24,865	Driven light with its exciter and starting motor at full voltage.
758	0 0	0	0	—	—	210	19·5	18·1	10,200	85	10,115	Driven not excited.
785	— —	—	—	—	—	205	8·0	18·0	4,100	15	4,085	Belt off motor.

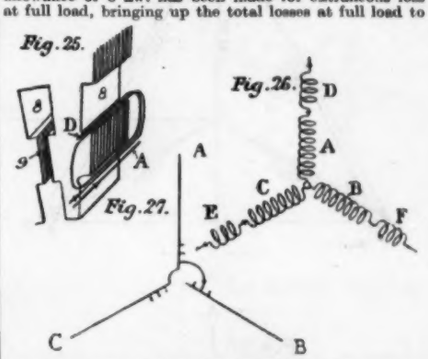
		24,865			
		10,115			
Exciting watts .. .. = 2,220	Exciting watts ..	14,750	Friction and windage, including exciter and starting motor	10,115	
		2,220		4,085	
	Iron loss	12,530 watts.		6,030	

Temperatures.	Part.	Temperature Deg. C. Reached.	Rise Deg. C.	Resistances at 14 Deg. C.	Ohms.
After 2 hours' run at 6,000 volts, no load	Stator core	39	22	Three-phase winding A–B ..	1·194
	Rotor winding	43	26	,, ,, B–C ..	1·185
	Exciter armature ..	44	27	,, ,, C–A ..	1·202
	Exciter commutator ..	44	27	One-phase	0·5435
	Air	17	—	One-phase compensation ..	0·102
				Single-phase winding, one coil ..	0·00442

TESTS ON SITE. May 13, 1917.

Order No. 338/16. Serial No. 1393. Three-phase single-phase balancer. 444 k.v.a.

Speed.	Exciting Amps.	Three-phase Side.						Single-phase Side.			Remarks.
		Volts.	Amperes.			Kilowatts.		Volts.	Amps.	Kw.	
			A	B	C	A–B	C–B				
750	29	6,100	3·2	3·4	4	9	14	224	0	0	Running light.
750	39	5,960	45·0	45·0	49	200	232	166	2,450	390	Full load. Arc pulled out to give maximum load.
750	39	5,980	13·0	13·0	18	38	83	Not readable	3,620	75	Carbon short circuited.



APPENDIX I.

SINGLE-PHASE LOAD ON THREE-PHASE GENERATOR.

The following figures were obtained from a test on an 8,000-k.v.a. star-connected three-phase generator, which

* It should be noted that any change which occurs in the field flux due to the single-phase load (except in so far as it is exterior to the damper) affects phase B as much as phases A and C.

* Except a very small inductive drop due to the three-phase load, which can be compensated for by the addition of a small choke coil in phase B.

was loaded up on another generator running as a synchronous motor so that the power factor of the load could be adjusted to zero. Measurements were made of the voltage on each leg of the star from the terminals to the star point, as well as between the terminals. The phases will be lettered A, B and C, in order of rotation. A single-phase load of 700 amperes at zero power factor was thrown upon terminals B and C. The voltages then were :—

		A	B	C
Phase voltage	...	4,130	3,950	3,820
		A–B	B–C	C–A
Terminal voltage	...	7,150	6,600	6,950

It is very commonly found on three-phase machines that the phase voltages are increased by higher harmonics, so that if a diagram is made with the three-phase voltages as vectors radiating from a point, and with the three terminal voltages forming the sides of a triangle, the centre point of the star forms the apex of a low tetrahedron, the altitude of the apex depending upon the amplitude of the harmonics. Notably when the phase voltage contains a pronounced third harmonic, which is absent on the terminal voltage, the altitude of the pyramid will be considerable. In this machine each phase winding was short-chorded by 60 deg., so that it occupied a virtual coil-width of 120 deg. This had the effect of eliminating the third and ninth harmonics in the phase E.M.F. wave. The winding factor of the fifth harmonic was only about 0·165, and that of the seventh harmonic 0·118.* The excess of higher

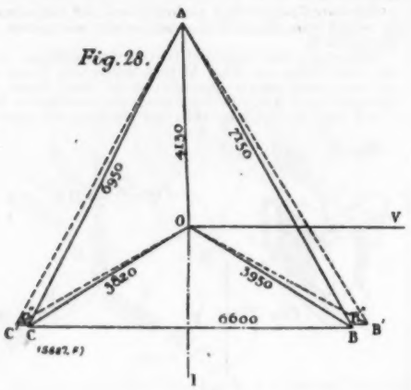


Fig. 28.

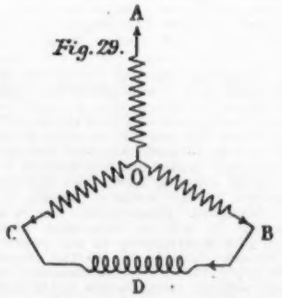


Fig. 29.

harmonics in the wave-form of the phase voltage over those in the terminal voltage appears to have been of very small value, because we find, when we set out the vector diagram with the voltages given above, that the apex of the pyramid has such a small altitude that the diagram may be regarded for practical purposes as lying in a plane (see Fig. 28). This clock diagram is supposed to revolve in an anti-clockwise direction, and the senses of the vectors must be taken with reference to Fig. 29, in which the arrow-heads show the directions taken as positive in each wire. Particular regard must be had to the direction of the current taken as positive through the single-phase load D. The vectors representing the voltages B and C are only 116 deg. apart. The values of the voltages, and the angle between them, seem to be sufficiently well accounted for by the ordinary theory of voltage drop in generator windings. The true reactive drop in the winding appears to have been about 7 per cent. of the terminal voltage. This figure agrees very well with the value obtained by the short-circuit test on the same generator. The resistance drop was only 0·375 of 1 per cent., and is almost negligible.

In Fig. 28 the author has set out the terminal voltage of B C as the radiating vector O V, and the current of 700 amperes as the vector O I lagging 90 deg. If we now assume that at no load the voltage in phase B was 4,130 and occupied position O B′, making an angle of 120 deg. with O A, and that the phase voltage in C was also 4,130 volts and occupied position O C′, also at 120 deg. from O A, we see that the allowance of an inductive drop of 7 per cent. in windings B and C, as shown by the vectors B′ B″ and C′ C″, brings us almost exactly on B and C, as ascertained by actual measurements.

It will be noticed that the vector C′ C″ is taken in the sense opposite to that of B′ B″; this is because the current O I is drawn on the convention that the arrow-head on O C (Fig. 29) is the positive direction along that wire. If, then, we are to draw the vector C′ C″ on the convention that the arrow-head on O C is the positive direction along the circuit, it must be set out in the sense as shown in Fig. 28.

From the fact that the construction shown in Fig. 28 gives us so very nearly the figures obtained on test, we can apply a similar construction for obtaining the displacement of voltage caused by a single-phase load, which forms a small proportion of the full-load rating of the machine, and at power factors higher than zero. If, for instance, we put upon the 8,000-k.v.a. 6,600-volt generator a load of only 140 amperes at a power factor of 0·7, we obtain a clock diagram (as shown in Fig. 30) in which the disturbances in the voltages of the system are as indicated in the following table :—

		A	B	C
Phase voltage	...	3,820	3,800	3,760
		A–B	B–C	C–A
Terminal voltage	...	6,620	6,530	6,540

We see from this that where a single-phase load forms only a small part (say not more than 20 per cent.) of the total load on a three-phase station, it may be thrown directly upon one of the phases of a three-phase generator without causing a serious want

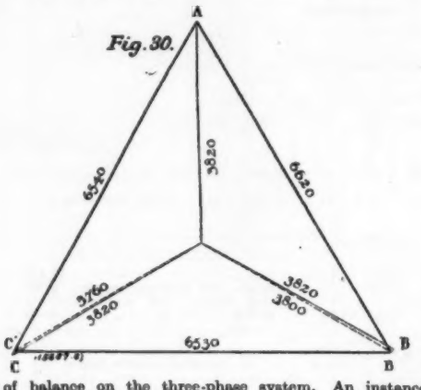


Fig. 30.

of balance on the three-phase system. An instance of this kind is found at Bradford, where single-phase furnaces of 400-kw. capacity are thrown on and off polyphase mains without causing a noticeable unbalancing of the voltages.

Single-Phase Armature Reaction.—The ratio of the field amperes on three-phase short-circuit (700 amperes per phase) to the field amperes on no load was 0·705 on the 8,000-k.v.a. generator referred to above. When the single-phase short-circuit current of 700 amperes was put upon phase B–C, the ratio of the field amperes on single-phase short-circuit to the field amperes at no load was 0·46. It is generally found that the field ampere turns on single-phase short-circuit are from 0·65 to 0·75 of the field ampere-turns, on three-phase short circuit, for the same armature current per phase. The exact value of this ratio depends upon the width of the pole arc and upon the efficiency of the amortisseur. Machines having a cylindrical field magnet distributed according to the ordinary plan, and having a very effective amortisseur, have a ratio in the neighbourhood of 0·65.

APPENDIX II.

Elimination of the Single-Phase Power Component without obtaining a Balance of Phases.

Let the current in the lines A, B and C be :—

$$i_a = 100 \sin \omega t,$$
$$i_b = 75.4 \sin (\omega t - 115 \text{ deg.}),$$
$$i_c = 96.6 \sin (\omega t - 225 \text{ deg.}). \text{ (See Fig. 31).}$$

The three vectors representing these currents form the sides of a triangle with the arrow-heads shown in Fig. 32 running concurrently. This is therefore a possible current distribution in a star-connected system. Now let the voltages in the three legs be :

$$e_a = 100 \sin \omega t,$$
$$e_b = 2\text{6.2} \sin (\omega t - 115 \text{ deg.}),$$
$$e_c = 123.3 \sin (\omega t - 225 \text{ deg.}).$$

Multiplying out $e_a i_a$, $e_b i_b$ and $e_c i_c$ we find that the alternating components of the power come out :

$$5{,}000 \cos 2 \omega t,$$
$$7{,}780 \cos (2 \omega t - 230 \text{ deg.}),$$
and $$5{,}960 \cos (2 \omega t - 450 \text{ deg.}), \text{ or}$$
$$5{,}960 \cos (2 \omega t - 90 \text{ deg.}).$$

The three vectors representing these alternating components form the sides of a triangle with the arrow-heads shown in Fig. 2 following concurrently. Their vector sum is therefore zero ; that is to say, the load on the system is balanced according to Steinmetz's definition of balance, although the conditions (1) and (3) mentioned on page 691 *ante* are far from being met. We thus see that the definition of balance given on that page are not necessarily the same. If a system complies with conditions (1), (2) (3) and (4), then it will be balanced according to Steinmetz's definition ; that is to say, the sum of all the alternating components of the power is zero. But it does not follow that if the sum of all the alternating components of power is equal to zero the conditions (1), (2), (3) and (4) are also met.

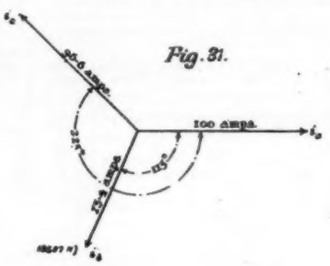


Fig. 31.

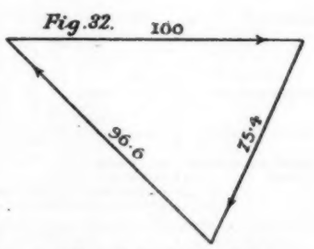


Fig. 32.

APPENDIX III.

Graphic Construction showing Balance of Power and Balance of Phases by means of a Choke Coil.

Let the three-phase system A, B, C, Fig. 33, be loaded* with a resistance and choke coil between the terminals A–B. Let the voltages in A, B and C respectively be represented by the vectors E_a, E_b and E in Fig. 34. Taking $e_a = E \sin \omega t$, we have :

$$e_{ab} = \sqrt{3}\, E \sin (\omega t + \pi/6).$$

First let us take the instance quoted by Steinmetz† where the power factor of the current A B is such that the current lags $\pi/6 = \phi$ behind the voltage, so that $i_{ab} = I \sin \omega t$. The alternating component of the power will be :

$$\tfrac{1}{2} \sqrt{3}\, E I \cos (2 \omega t + \tfrac{1}{3}\pi - \pi/6),$$
$$= \tfrac{1}{2} \sqrt{3}\, E I \cos (2 \omega t + \pi/6).$$

In order to neutralise this alternating component, we can put in circuit a choke-coil fed by a voltage :

$$e^1 = \sqrt{3}\, E' \sin (\omega t + \pi/6 - \beta) = \sqrt{3}\, E \sin (\omega t - \pi/6)$$

where $$\beta = \tfrac{1}{3}\phi + \tfrac{1}{3}\pi = \pi/12 + \tfrac{1}{3}\pi = \tfrac{1}{4}\pi.$$

This voltage can be obtained from the terminals A–C, as is shown in Fig. 33, lagging 30 deg. behind E_a.

The current through the choke coil is :

$$i' = I' \sin (\omega t - \pi/6 - \tfrac{1}{4}\pi),$$

and if the reactance of the coil be suitably adjusted so that I′ = I, then the alternating component of the power in the choke circuit is :

$$e' i' = \tfrac{1}{2} \sqrt{3}\, E' I' \cos (2 \omega t - \tfrac{1}{3}\pi - \tfrac{1}{4}\pi).$$

and as $\cos (2 \omega t - 5 \pi/6) = - \cos (2 \omega t + \pi/6)$ the two alternating components neutralise one another. Now in this special case it will be seen from Figs. 33 and 34, taking the direction shown by the arrow-heads as positive in each leg, that before the choke coil was added the current in leg A was I_{ab} and in leg B it was I_{bc}. After the choke coil is put in circuit the current through it is I_{ac} in leg A, and I_{ca} in leg C. Adding together I_{ab} and I_{ac}, we get I_a, as the current in A. Thus we see that the three legs carry equal currents at 120 deg. apart ; and as the voltages were assumed in balance we see that conditions (1), (2), (3) and (4) hold.

APPENDIX IV.

Choke-Coil Balancer giving Balance of Power without Balance of Phases.

In applying Steinmetz's method to the case of single-phase load, power factor 0·7, the question whether or not we get balanced currents depends upon the way in which we build up the voltage $E' \sin (\omega t - \beta)$ from the components selected from the three phases. Let the voltages in the three legs of the star be :

$$e_a = 1{,}000 \sin \omega t$$
$$e_b = 1{,}000 \sin (\omega t - 120 \text{ deg.}),$$
$$e_c = 1{,}000 \sin (\omega t - 240 \text{ deg.}).\ddagger$$

* S. P. Smith and R. H. Boulding, *Journal of the Institute of Electrical Engineers*, 1915, vol. liii, page 205.

* The example given here is the one given by Steinmetz (*ibid.*, page 326). The author shows in Fig. 34 how in this particular instance the phases are balanced. In Appendices II and IV examples are given in which the phases are not balanced, although the single-phase load is on the whole eliminated.

† *Ibid.*, page 327.

‡ The expression of angles of lag in degrees instead of in radians is adopted for general convenience in what follows. The maximum voltage is arbitrarily taken as 1,000 so as to get four significant figures without a decimal point.

These are shown in Fig. 35 by the vectors E_a, E_b and E_c respectively. Let the single-phase load be fed from terminals A and C.

$e_{ac} = 1{,}732 \sin(\omega t - 30 \text{ deg.})$ (see vector E_{ac}).

$i_{ac} = 1{,}000 \sin(\omega t - 30 \text{ deg.} - 45 \text{ deg.})$ (see Vector I_3).

As the arrow-head indicating the positive way through the single-phase load is opposite in sense to the arrow-head on phase C (Fig. 8), the vector O I_3 must be reversed (see O i_c) to represent the current in phase C.

The alternating component of the power is :

$$-\tfrac{1}{2} \times 1{,}732{,}000 \cos(2\omega t - 60 \text{ deg.} - 45 \text{ deg.}).$$

In order to neutralise this alternating component by means of a reactive load, we must make :

$$\beta = \tfrac{1}{2}\phi + \tfrac{1}{2}\pi = 22{\cdot}5 \text{ deg.} + 45 \text{ deg.} = 67{\cdot}5 \text{ deg.}).$$

Take $e' = 1{,}732 \sin(\omega t - 30 \text{ deg.} - 67{\cdot}5 \text{ deg.})$ (see vector E_c E'_b),

$i' = 1{,}000 \sin(\omega t - 30 \text{ deg.} - 67{\cdot}5 \text{ deg.} - 90 \text{ deg.})$ (see vector I').

There are many different ways in which we can produce the voltage e'. First let us take two transformers, one having a ratio of 1,000 to 765 connected across e_c and another having a ratio of 1,000 to 1,216 connected across e_b. If the secondaries of these are connected so as to give the resultant :

$$\frac{1{,}216}{1{,}000}\, e_b - \frac{765}{1{,}000}\, e_c :$$

we shall get the vector E'_c E'_b of right phase and right amplitude. In order that these transformers may preserve their ratio of transformation and take their proper load, it is necessary (with this method) to carry a fourth wire to the star point of the generator ; because the vector sum of the three currents is not equal to zero. If we put in circuit with these secondaries a reactive coil of negligible resistance having a reactance of 1·732 ohms, so that it takes the current I' having a maximum of 1,000 amperes, it will be found that the alternating components of the power will balance out. When 1,000 amperes flow through the secondary in phase C, the current in the primary will be 765 (shown by the vector O I'_c); and the current in the primary of phase B will be 1,216 amperes (shown by the vector O I'_b). The vector representing the current of the original single-phase current in phase C is O i_c. To this add I'_c and obtain O I_c, the total current in C. We now see that the three currents I_a, I'_b and I_c are unbalanced and do not form a closed triangle, so that they cannot flow without the assistance of a fourth wire. Their values are :

$i_a = 1{,}000 \sin(\omega t - 75 \text{ deg.})$,

$i_b = 1{,}216 \sin(\omega t - 120 \text{ deg.} - 67{\cdot}5 \text{ deg.})$.

$i_c = 1{,}000 \sin(\omega t - 240 \text{ deg.} - 60 \text{ deg.})$.

Nevertheless the alternating components of the power taken in all phases balance one another out. This is seen from Fig. 36, which is a clock diagram of the double-frequency vectors obtained by taking the alternating components of the products $e_a i_a$, $e_b i_b$ and $e_c i_c$. These are :

$\tfrac{1}{2} \times 1{,}000{,}000 \cos(2\omega t - 75 \text{ deg.})$,

$\tfrac{1}{2} \times 1{,}216{,}000 \cos(2\omega t - 240 \text{ deg.} - 67{\cdot}5 \text{ deg.})$.

and $\tfrac{1}{2} \times 1{,}000{,}000 \cos(2\omega t - 480 \text{ deg.} - 60 \text{ deg.})$.

These form a closed triangle, notwithstanding the fact that the currents are unbalanced.

APPENDIX V.

METHOD OF CHOOSING THE COMPONENT VOLTAGES FROM THE THREE PHASES IN ORDER TO BUILD UP E' SIN $(\omega t - \beta)$ SO AS TO GET BALANCED CURRENTS IN THE CASE OF A CHOKE-COIL BALANCER.

The triangle I'_b O I_c (Fig. 37) is intended to be the triangle whose sides shall represent the final resultant currents in phases A, B and C. The base I'_b O is necessarily parallel to I' and lags 7·5 deg. behind the vector O E_a. The vector O I_c is made up of O i_c, which is known, and i_c I_c, whose direction is known, namely, that of O I'_c the current in the primary of the transformer in leg C. The current in the primary of the transformer in leg B is I'_b O. The current in A is I_c I'_b, which is made up of the single-phase current I_3 plus the transformer primary current I'_c I'_b ; and in order that the triangle of currents shall be closed, I'_b O must be greater than I'_c O by an amount I'_b I'_c, which shall be just equal and opposite to the current in the primary of the transformer in leg A, namely I'_c I'_b. Now the currents in the primaries of the transformers are directly proportional to the number of turns in the secondaries. Therefore the number of turns in the secondary of B shall exceed that of C by a number which shall be equal to the number of turns in the secondary of A. We therefore necessarily have two isosceles triangles, O e E'_c and E'_b E'_c built up by the voltage vectors having the sides O E'_c = O e and E'_b e = E'_b E'. The number of turns in the secondaries of the transformers (taking the primaries as 1,000) is most easily determined by taking the ratio of the sines of the angles in the triangles I_c I'_c I'_b and O i_c I_c, as follows :

$$\frac{I'_c\, I'_b}{I'_c\, I_c} = \frac{\sin 7.5 \text{ deg.}}{\sin 60 \text{ deg.}} = 0.151,$$

$$\frac{i_c\, I_c}{i_c\, O} = \frac{\sin 52.5 \text{ deg.}}{\sin 60 \text{ deg.}} = 0.915,$$

$$I'_b\, O = 0.151 + 0.915 = 1.066.$$

Therefore the turns in the secondaries of A, B and C are 151, 1,066 and 915 respectively. With 1,000 volts on each of the three primaries of 1,000 turns we get :

E'_c O = 915 volts

O E'_b = 1,066 volts

E'_b E' = 151 volts

and the vector sum of these is E'_c E' = 1,732 volts, which gives us the voltage e' in the correct phase. If now we put in circuit with this a reactance of 1,732 ohms we get 1,000 amperes lagging 90 deg. flowing in the secondaries, and this calls for currents in the primaries of the same phase (assuming perfect transformers) the amounts of which are :

	Amperes.
Phase A	151
Phase B	1,066
Phase C	915

If now we add the 1,000 amperes I_3 in phase A to I'_c I'_b we get 1,066 amperes total in phase A ; and if we add the 1,000 amperes O i_c to i_c I we get O I_c = 1,066, so that all three currents are equal and at 120 deg. to one another. The angle of lag of each current behind its E.M.F. is 67·5 deg. in each case. The alternating components of the power in the three circuits are equal, and the double-frequency vectors representing them are 120 deg. to one another. They therefore cancel out (see Fig. 38).

(To be continued.)

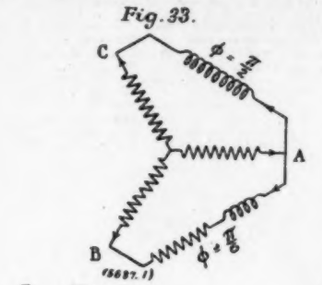


Fig. 33.

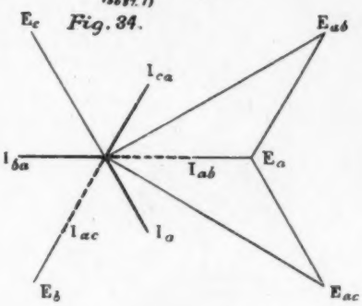


Fig. 34.

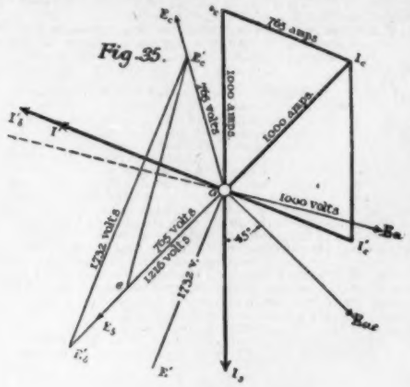


Fig. 35.

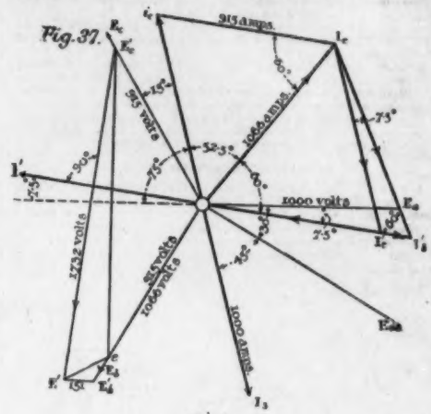


Fig. 37.

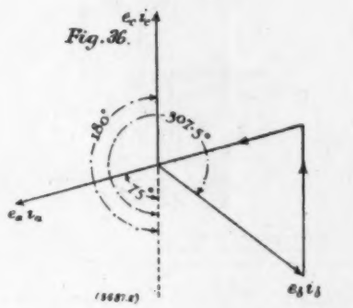


Fig. 36.

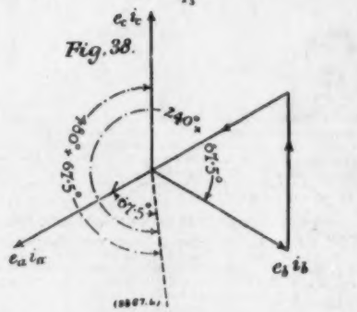


Fig. 38.

A WELDED MOTORSHIP.—In 1917, when the system of welding known as the Quasi-arc was placed before Sir George Carter, the managing director of Messrs. Cammell Laird and Co., he decided to give it a trial. In conjunction with Lloyd's Register of Shipping, a series of tests were instituted to decide whether welded joints would be satisfactory in a ship. The tests were arranged to obtain information not only on the tensile strength, but also on the elastic properties of welded metal, and its ability to resist alternating stresses. The results of the test showed that if reasonable precautions were taken in the manufacture and working of the welded material, and if certain limits were imposed, the material could be used with success. The next step was to build a welded ship and test everything out finally. All the steel for the vessel is now delivered to the shipyard ; a large quantity has been prepared, and the process of erection and welding up of the various parts is proceeding rapidly. A considerable weight of material is on the slipway. The vessel is of the coasting type, 150 ft. long. She will carry 500 tons deadweight, and have cargo capacity of 26,000 cub. ft. Several comparisons have been made between riveted and welded joints, the latter showing very much better results. For instance, where transverse and longitudinal girders cross one another, by using a double fillet weld it is possible to maintain 95 per cent. or even 100 per cent. of the strength of the solid plate across such junctions, whereas with riveted connections the strength of the girder which is cut is practically reduced to nothing. With such joints, there is no necessity to distinguish between the longitudinal and transverse systems of ship construction, since the full strength can be maintained in both directions. Girders under decks can be fitted entirely between the beams, thereby increasing the head room on passenger decks and the cargo capacity in holds. The principle is capable of extensive application in other advantageous ways. A very important consideration is naturally cost. It is possible under several heads to save steel in a welded ship. This not only helps to reduce the first cost, but makes the ship lighter than a riveted ship. The result is that she can carry more cargo. Messrs. Cammell Laird's welded ship will be unique in that she will be fitted with the Camellaird-Fullagar engine, an oil motor of the Diesel type. It is very compact, developing 50 per cent. more power for the same space occupied by other engines, and running at low revolutions and consequently giving high propeller efficiency. The turning moment is even and perfectly balanced. There are no direct stresses on the framing as the piston loads are balanced. There is only one working valve to each cylinder and no vibration.

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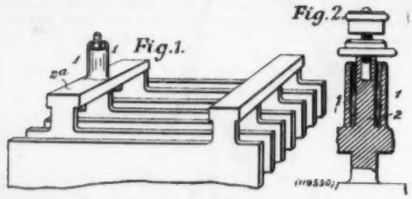
ELECTRICAL APPARATUS.

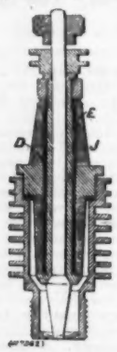
119,530. The Fuller Accumulator Company, Limited, Chadwell Heath, and J. C. Wood, Derby. Electric Storage Batteries. (4 *Figs.*) October 3, 1917.—This invention relates to electric accumulators of the kind wherein alternate plates are connected to a common bar provided with a terminal lug. According to this invention, an electric storage battery or accumulator of the kind above described is provided with a terminal lug 2 having a sleeve or annulus 1 surrounding the terminal stem



of the cell, the said sleeve being integrally connected to the cross bar 2a at the lower end only, and spaced apart from the terminal stem, the remaining part of the sleeve being free from any metallic contact with the said stem, so as to provide a continuous surface of considerable length for the creeping of the acid before reaching the terminal stem, with or without petroleum jelly or paraffin wax in the space between the sleeve and the terminal stem of the cell. (*Accepted October* 16, 1918.)

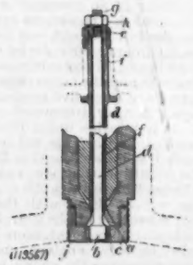
GAS ENGINES, PRODUCERS, HOLDERS, &c.

117,362. L. S. Clarke, Catford. Sparking Plugs. (2 *Figs.*) October 17, 1917.—This invention relates to sparking plugs for internal combustion engines, and has reference to that type of plug in which the insulation between the central electrode and the body or casing of the plug consists of a mica wrapping and mica washers, and in which the central electrode with its washers can be removed as a unit from the body or casing of the plug. A sparking plug, according to this invention, comprises



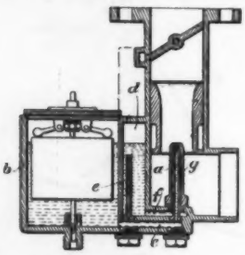
a metal tube or sleeve containing the central electrode J, one or more mica wrappings D round the central tube and mica washers E held in compression around the wrappings D, the mica washers below the screw gland of the plug being coned to provide a long surface out of contact with the interior of the body of the plug and the central electrode J with its tube and insulation being removable from the body without loosening the washers or disturbing their relation with the tube (*Sealed.*)

***119,567. A. R. McEwan, Greenock. Internal-Combustion Engines.** (1 *Fig.*) October 27, 1917.—This invention relates to fuel injection valves particularly adapted for use with



Diesel engines. The fuel control valve *a* carries at its inner end the cylindrical plug-piece *b* adapted to move longitudinally in a small cylinder whose walls are formed with grooves, which are normally covered by the plug-piece, but are uncovered thereby simultaneously with the opening of the fuel valve, so that the fuel supply openings are protected from the combustion gases and are uncovered only during the injection of fuel. The fuel control valve *a* takes the form of a tube member enclosing a spindle *d* whose inner end carries the plug-piece *b*, so that the control valve for the fuel and the protecting plug for the fuel orifices may be capable of adjustment relatively to each other so as to vary the opening of the fuel passages and so control the fuel jets. For the adjustment of the plug piece *b* relatively to the valve *a* the spindle *d* has a screw threaded end *e* for engagement with the tapped end of the sleeve *f* carrying the valve *a*; the spindle having its extreme end squared at *g*, whilst the screw-threaded part has a lock nut *h*. The small cylinder for the plug *b* is preferably formed in a cap *j* screwed to the inner end of the removable fuel injection mechanism and the grooves *c* are preferably formed so as to cause the fuel jests to impinge against each other and thereby thoroughly break up the fuel. (*Accepted.*)

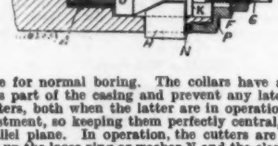
119,508. J. Fagard, Birmingham. Carburettors. (3 *Figs.*) September 29, 1917.—This invention relates to carburettors having an auxiliary nozzle which comes into action at high engine speeds so as to assist the main jet and give an increased supply of fuel for obtaining maximum power. According to the present invention, an auxiliary nozzle in the choke tube constantly communicates with a fuel well which is open to the atmosphere only through a restricted aperture, and the arrangement is such that at medium speeds the fuel is unable, under the influence of the small depression in the well, to rise high enough to pass to the auxiliary nozzle, but at high speeds the depression is increased sufficiently to cause the said fuel to rise and pass to the auxiliary nozzle, which thus assists the main jet in order to maintain a correct mixture. The main jet *a* is supplied from the float chamber *b* through a passage *c*, and the open well or chamber *d* is also supplied from the passage *c*, through a vertical tube or submerged jet *e* whose upper end terminates at a suitable distance below the normal level of the fuel in the float chamber. From the bottom of the open well a passage *f* leads to an auxiliary jet *g* surrounding the main jet *a*. This auxiliary jet *g* is used for assisting the pick-up or acceleration of the engine



when the throttle is opened fully. To ensure its going out of action as soon as the acceleration has been effected, a restriction of very small bore, acting as a resistance to the flow of fuel, may be placed in the main passage *c* between the float chamber *b* and the upstanding supply tube *e*, so that the level in the said tube, as the suction of the main jet increases, quickly falls below its upper end and the supply of fuel ceases. The main jet *a* is of such a size that it will supply the proper quantity of fuel at medium speeds, but for high speeds it will not supply sufficient. To increase the supply of fuel at highspeeds, the sole air inlet of the open chamber or well is made of a restricted size, with the result that as the speed and suction increase the pressure of the air within the chamber *d* is reduced below that of the outside atmosphere counteracting the effect of the resistance in the main passage, and preventing the petrol from completely emptying from the vertical supply tube *e* in the chamber; whilst when a certain speed is reached the level in said supply tube *e* commences to rise, due to the continued reduction of pressure in the chamber *d*, until, at high speeds, fuel is again delivered by the said tube into the chamber, being then taken up by the auxiliary jet *g* to supplement that delivered by the main jet. (*Accepted October* 16, 1918.)

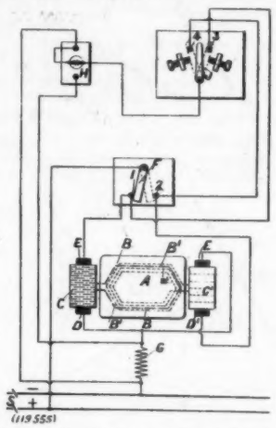
MACHINE AND OTHER TOOLS, SHAFTING, &c.

119,545. A. Lees, Halifax. Boring and Facing Bars. (4 *Figs.*) October 9, 1917.—This invention relates to boring and facing bars for boring operations in capstan, turret and ordinary lathes, boring and turning mills, and all kinds of drilling machines of the type having renewable and expandable cutters. A screw thread A and B is formed upon each end of the expansion or operating spindle C. The thread A operates within a corresponding recess D in the bar casing E, whilst upon the other thread B is a nut F. A square G is also formed upon this end of the spindle for turning same to adjust the cutters H for the bore desired. In place of the inclined flats hitherto employed for engaging the cutters for expansion purposes, two collars J, K, are formed on the spindle a suitable distance apart and of a diameter approximating a further cylindrical recess L in the end of the casing. The collar J forms the base of a cone M, and the cutters which fit between these collars have their bases shaped so that a portion rests upon the cone and a portion upon



the spindle for normal boring. The collars have a sliding fit within this part of the casing and prevent any lateral shifting of the cutters, both when the latter are in operation or during their adjustment, so keeping them perfectly central, and in the same parallel plane. In operation, the cutters are gripped by tightening up the loose ring or washer N and the clamping nut P in the known manner, and may be formed so as to both bore and face if desired, then the nut F is screwed up against the nut P for rigidly locking both cutter and spindle against any independent movement. For adjusting the cutters for a larger or different bore or for facing, the nuts F and P are first slackened, when the spindle may be turned by means of the square G. The revolving of the spindle as aforesaid causes the screw A to move the same outwardly and the conical portion M to engage the corresponding parts of the cutters H, thereby expanding the same as desired. When the adjustment is completed or in accordance with the bore desired, the mere tightening of the nut F renders the whole perfectly rigid and again ready for use. (*Accepted October* 16, 1918.)

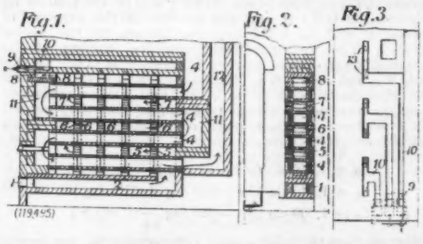
119,555. G. Stirk, E. Stirk, R. Stirk and J. G. Stirk, Halifax. Reversing Planing Machines. (1 *Fig.*) October 17, 1917.—This invention relates to direct-current electric reversing motors and to means for reversing at the end of each stroke on planing machines and other reciprocating machine tools. The armature A has windings in ratio of one turn per section at B, and at B1 of three turns per section. One coil only of each winding is shown in the diagram, and the field windings of the motor being quite normal are not shown. C, C1 represent commutators connected to the single and triple windings B, B1, respectively; E, D are brushes operating in conjunction with commutator C, and E1, D1 with commutator C1. F is a two-way change-over switch operated by the reversing dogs on the machine and cross-connected with the contactor H and frictions witch J. Assuming field circuit is already complete the action of the motor is as follows: On closing the main switch S and with change-over switch F making contact at 1, a circuit is completed from the negative main through resistance G, brushes D and E, commutator C, single turn winding B, switch F to positive main, and the armature commences to revolve say in clockwise direction. Friction switch J being actuated by one of the reversing shafts of the machine also rotates in the same direction and makes contact at 3, whereby a circuit is completed



from positive main through the two-way switch F at 1 and friction switch J at 3, exciting coil of contactor H, to negative main at one end of the resistance G. The other end of resistance G being connected to the contactor H then closing, the latter now short circuits resistance G, and single-turn winding B and commutator C are in use, the motor running at the fast speed in clockwise direction. Upon the usual reversing dogs throwing over the switch F to make contact at 2, winding B1 is similarly brought into play and the motor begins to rotate at the proportionate reduction in speed and in the opposite direction as indicated by the reversed brush connections, the circuit being as follows: From negative main through resistance G, brushes E1, D1, commutator C1, triple-turn winding B1, two-way switch F making contact at 2 as shown in dotted lines, to opposite main. At the commencement of the motion in opposite direction the friction switch J is making contact at 3, but contactor H is open because the changing over of switch F has connected both ends of its coil to the negative main, consequently no current flows through it. Following upon the friction switch J being carried over anti-clockwise to correspond with the reversed direction of motor and machine gearing, contact is made at 4 and a circuit immediately completed from positive main through two-way switch F at 2, friction switch J at 4, and coil of contactor H to negative main at one end of the resistance G as before described. Winding B1 is now direct across the mains and the motor runs at the corresponding speed in anti-clockwise direction. (*Accepted October* 16, 1918.)

MINING, METALLURGY, AND METAL WORKING.

119,495. J. R. C. August, Halifax, and H. V. Hobson, Halifax. Regenerative Furnaces. (3 *Figs.*) September 26, 1917.—The present invention relates to improvements in regenerative furnaces. According to the present invention, means are provided to control the secondary air at, or substantially at, the place where the stream or streams of pre-heated secondary air meet the main streams of burning gas with a view to completing the combustion of said gas. The secondary air for promoting combustion in a regenerative furnace enters at 1 into the flue 2 of the furnace. The air from 2, passes back to and fro along the outside of the exhaust flues 4 of the furnace, axially along the same, along passages 5, 6 and 7, and then into the flue 8 controlled by a damper or throttle 9, led into a passage 10,



communicating directly with the flue conveying the furnace gases, at which point complete combustion will commence to take place. The exhaust flue 4 is united by headers 11 to allow the gases to pass to and fro for a long distance to provide a thorough heating for the air previous to passing into the exhaust flue 12. As will be seen from Fig. 2, the exhaust flues 4 are almost completely surrounded by passages 6, 7 and 8 conveying the secondary air. The passages 10 may be arranged in any desired number; three are shown in Fig. 3 by way of example. These passages lead in this case to the entrances 13 of a pair of combustion chambers and are each controlled by a damper or throttle 9. It is obvious, of course, that each passage 10 may, if desired, only communicate with one chamber or with a number of chambers, and can be controlled from the side. (*Accepted October* 16, 1918.)